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THE RIO GRANDE IRRIGATION PROJECT.

THE LARGEST RESERVOIR IN THE WORLD.

By Newton Forest.

The construction of the Engle dam is soon to begin, the Secretary of the Interior having given his sanction to the undertaking. This huge piece of masonry is to obstruct the Rio Grande and is to be built in connection with what is known as the Rio Grande irrigation project. This project lies in New Mexico and Texas and includes several units, namely, the Rio Grande dam, the Leasburg Diversion dam, and the dam which is now to be built. The Leasburg Diversion dam already has been completed, the water which it stores being sufficient to irrigate twenty-five thousand acres of Mesilla valley.

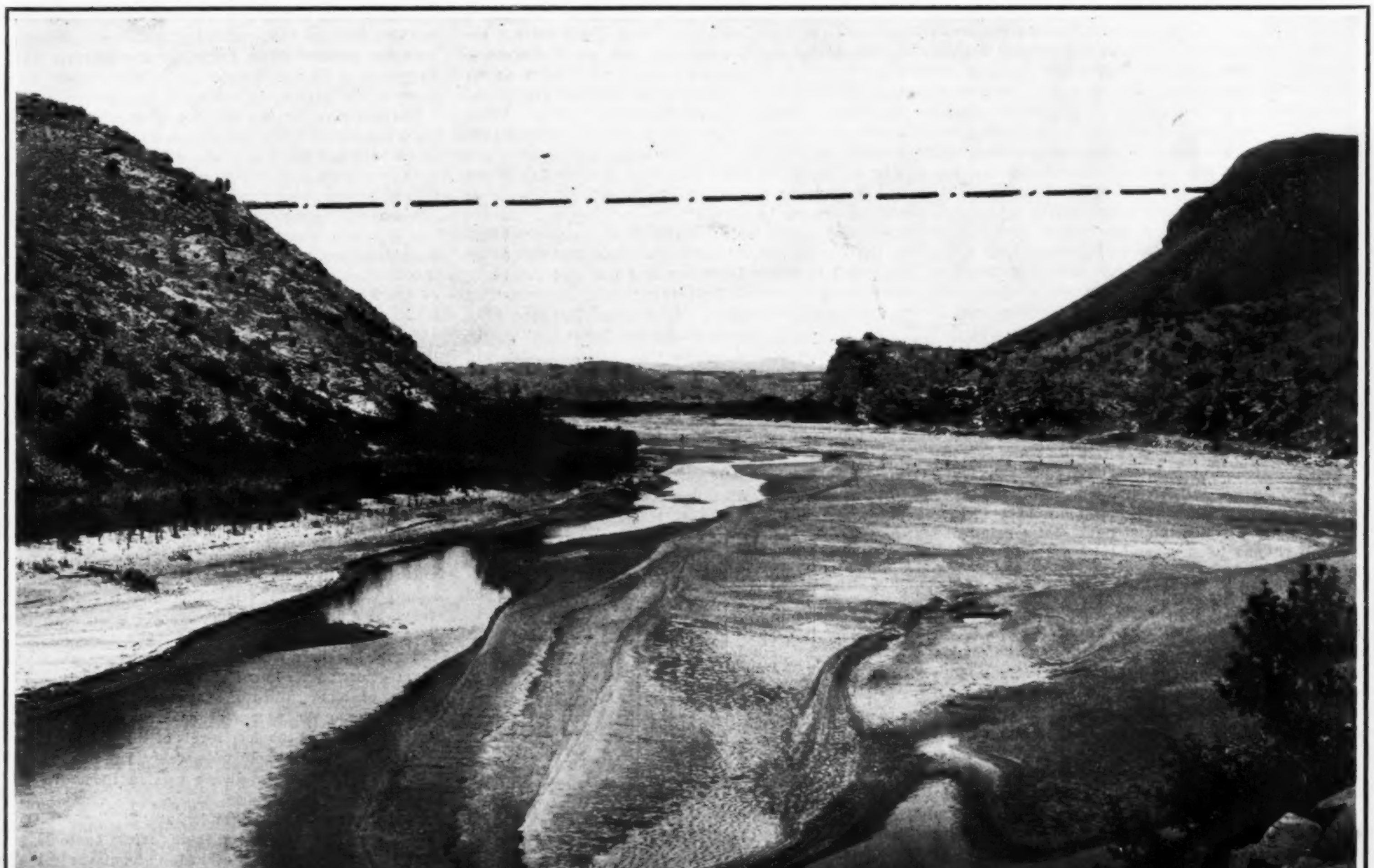
The reservoir that will be inclosed by the Engle dam will be one of the largest artificial bodies of water in the world. It will be forty miles in length and have a capacity of 2,000,000 acres-feet, or ample for the 180,000 acres of land to be supplied by its waters. The dam itself, from bed rock foundation to top of parapet walls or crest, is to be 265 feet high. At the bottom it will be 180 feet thick, tapering at the top to a width of 20 feet. Its total length is to be some 1,400 feet. To hold in check the vast amount of water to be conserved, the projected dam will be arched up-stream on a six-degree curve. The cost of the entire project is estimated at $7,200,000, or an average of $40 an acre on 180,000 acres. This is below the value of irrigated land in the valley, and the government will, therefore, not only eventually get every dollar of the vast expenditure back, but will extend the first aid in the transformation of a wonderful desert into one of the most productive sections the country has ever known. The main item of the cost, of course, is the dam itself, approximating $5,300,000. The greatest cost of any one single item of material will be that of cement, the structure requiring some 300,000 barrels to hold together the hundreds of thousands of blocks of stone of which it will be composed.

A CROP ON IRRIGATED ALFALFA FIELD.

Particular interest attaches to the selection of this reservoir site from the fact that the region which is to be benefited by the waters conserved is to-day being irrigated by the oldest irrigation systems in use in this country. The history of the Rio Grande Valley is the history of New Mexico. Before the advent of the Spaniards under Marco de Niza in 1539 this territory had been the home of untold generations of sedentary tribes of Indians, as well as of nomadic predatory tribes. Many ruined pueblos and houses of stone in the shelves of the rocky cliffs attest to this period of settlement. Following Niza, and guided by him, Francisco Vasquez Coronado came to this country in 1540, and used the valley of the Rio Grande as a base for his explorations into what is now Arizona, Texas and Kansas. From this time on the history of this valley is one of conquest and revolt, the Indians not being entirely overcome until the close of the seventeenth century. Henceforward New Mexico grew in importance, new towns being established in the Rio Grande Valley, where the colonists learned to make use of the crude but often extensive irrigation works that had been established probably centuries before by the aboriginal inhabitants. This portion of the Rio Grande Basin is known as the Mesilla Valley, and lies on both sides of the river between two spurs of the Rocky Mountains. Beginning at the north at Fort Seldon it extends almost to the corporate limits of El Paso on the south. On the east and west its boundaries are the lofty ranges of mountains, the highest of which, the Organ Mountains, rise to the height of 8,000 feet above the level of the sea.

The first appropriations of water are for 180,000 acres. Of this 25,000 acres lies in Old Mexico, and the remainder in Texas and New Mexico. The Reclamation Service promises water for no more than 180,000 acres,

(*Continued on page 104.*)



LOOKING UP THE RIVER THROUGH THE DAM SIDE. DOTTED LINE INDICATES HEIGHT OF THE DAM.

RIO GRANDE IRRIGATION PROJECT.

NATURE OF THE EARTH'S INTERIOR.*

ITS RELATION TO THE QUESTION OF DEEP MINING.

BY PROF. E. H. L. SCHWARZ, A.R.C.S., F.G.S.

Geology has inherited many beliefs from mediæval times, which still remain part of the creed of those who profess to base their ideas on solid fact. One of the most ingrained of these beliefs is that of a hot, liquid interior of our earth. It was proved to the satisfaction of the Mediterranean nations by the flows of lava from the chimneys of Etna and Vesuvius, and it was the civilization of these nations which spread and was taken up by the rest of the world so that ideas started in Italy became the heritage of all thinking men. Then Kant and Laplace, with their nebular hypothesis, put this liquid globe theory on a basis which satisfied every condition then known or imaginable. If, however, we examine the premises of the Laplacian theory; if we put ourselves outside our hereditary tendencies and dispassionately review the whole question, we shall find that all the so-called proofs and reasons for the earth's interior being hot and liquid rest on arguments which will not hold water. The lava of Etna, for instance, cannot come from any profound depths. The gaseous sphere with which Laplace commences his history of the solar system could not have existed, as the kinetic energy of gaseous molecules would have prevented their being whirled round in a coherent globe; the solar system, in fact, at the present day, instead of affording testimony in favor of the nebular hypothesis, contains so many contradictory evidences that a new theory of its origin has become imperatively necessary.

Not only is the philosophy of modern geology destructive of the old idols of theory and hypothesis, but it is constructive, perhaps merely to set up a new idol, but nevertheless the new hypothesis of the nature of the earth's interior rests on a basis of probable fact and stands four-square to modern knowledge. I refer to Prof. T. C. Chamberlin's Planetismal hypothesis. I cannot here explain the hypothesis as a whole; it is available to all in the Text Book of Geology published by Profs. Chamberlin and Salisbury; suffice it here to state that the theory necessitates the gradual growth of the earth from a small, solid nucleus by the infalling of meteorites and that it is still growing. My purpose in the present paper is to examine some of the results of the physical investigation of the surface of the earth which prove by undeniable evidence the existence of a solid interior of the earth, which we postulate from theoretical considerations if we accept the planetismal hypothesis; and as none of the processes of earth building explained by this hypothesis require a hot interior, we are left with presumptive evidence that it is cold.

In the first place we are now enabled to actually test the physical condition of the interior of the earth by means of vibrations which travel through it. When an earthquake originates at any one place there is sent forth a vibration which affects the outer siliceous surface only; the latter heaves as an ice-floe would upon the surface of an agitated ocean. Besides this surface quake there are vibrations which travel by the brachistochronic or the shortest possible paths right through substance of the earth's interior to a spot on the other side, where the vibration can be recorded. Now, when a shock is communicated to a body, there are two kinds of waves that are set up; there is the normal or compressional vibration, which can be propagated in any medium, solid, liquid or gas; but if the medium is solid, there is a further transverse wave, which, on account of its being distortional, cannot be propagated in a liquid or gas. The velocities of these two waves are very different, and when we find on the recording seismograph two distinct vibrations separated by a definite time interval, which is proportional to the distance traversed in the earth's interior, then we can state that the earth's interior is solid throughout. Indeed, we can say more than that. The difference in the rates of the two waves is such as would be experienced in a medium twice as rigid as steel. Arrhenius has maintained that a gas might be so compressed that it becomes as compact as a solid, but then it could not transmit distortional waves, which can only be propagated in rigid substances, and Arrhenius's theory of the gaseous interior of the earth must fall to the ground on that fact.

There is another curious fact connected with earthquakes which bears on our subject. For direct paths between two points in the earth's crust less than 1,000 miles apart, the one being that at which the earthquake occurs and the other being that at which it is recorded, the speed of transmission is such as is found in waves propagated through ordinary rocky material; but if this straight path penetrates more than 30 miles below the surface, the waves are accelerated. There is, as it were, a globe of high elasticity, twice as rigid as steel, immediately below 30 miles in the earth's crust, whereas all above is not materially different in physical condition from the rocks exposed on the surface. If the earth's interior were molten, let alone gaseous, it would be impossible from the laws of diffusion for this sharp demarcation between crust and interior to remain in existence.

Having established the fact that the earth's interior is a solid, let us now examine the temperatures observed in the earth's crust.

As we go downward in the earth's crust there is a distinct increase of temperature below the variable zone affected by the climatic and seasonal conditions. This increment is on an average about 1 deg. F. for every 60 feet. But what is this average calculated upon? It is obtained by massing all the figures from various rock systems and dividing through. If now we take the older and younger rock systems we shall find that the former, nearer the earth's centro-sphere, have a temperature increment of only 1 deg. F. in every 200 feet, whereas the latter may have as rapid an increment as 1 deg. F. in every 28.1 feet (Anzin, near Valenciennes). In the British Isles we may obtain in this confined area alone differences ranging from an increment of 1 deg. F. for every 34 feet to 1 deg. F. for every 130 feet.

To explain the earth's temperature we have no reason to postulate an internal molten sphere of rock; in fact, were there any heat at all in the center of the earth, life on the surface would be impossible from the enormous additional heat received by the crust by radiation. The source of this earth temperature lies firstly in the chemical changes which go on in the rocks themselves and secondly in the fact that all siliceous rocks contain radium, and lastly in the movements in the earth's crust, which produce frictional heat.

To take the first case first. The earth's crust is a veritable chemical laboratory, in which reactions are always going on. The simplest process is the oxidation of pyritic carbonaceous shale rock, such as we find abundantly in the Lias of Europe and above the Dwyka Conglomerate in South Africa. When water containing oxygen gains access to this rock through cracks, there is immediately a reaction which sets up so much heat that not infrequently steam and sulphurous vapors are given off and escape at the surface as in solfataras near volcanoes. In the Kimberley mines, which pierce the carbonaceous shale of the Dwyka series near the surface, this action has happened in many instances, and the reef has burnt for years. It must be remembered, however, that the reaction is reversible. An oxidized sediment deeply buried may become pyritized and hence heat will be absorbed and locked up so that pyritic shales will show abnormally high temperature increments near the surface and abnormally low ones below the range of surface waters.

The following figures are given by Sir A. Geikie for the Rose Bridge Colliery Shaft at Wigan, and will show at a glance how dependent on the rock encountered is the temperature increment.

Depth, in Yards.	Increment, in Feet.	Increase, in Feet, for 1 Deg. F.	Temperature, Fahr.	Increase.
558	...	....	78.0	...
605	141	70.5	80.0	2.0
630	75	28.0	83.0	3.0
663	99	49.5	85.0	2.0
671	24	24.0	86.0	1.0
679	24	24.0	87.0	1.0
734	165	110.0	88.5	1.5
745	33	66.0	89.0	0.5
761	48	32.0	90.5	1.5
775	42	28.0	91.5	1.0
783	24	48.0	92.0	0.5
800	51	51.0	93.0	1.0
806	18	36.0	93.5	0.5
815	27	54.0	94.0	0.5

In one place, therefore, the râte of increase may vary from 1 deg. F. to every 24 feet to 1 deg. F. for every 110 feet.

In the deeper-seated portions of the earth's crust, where the pressure is so enormous that solids become potential liquids and the molecules of which they consist have the mobility of those liquids, silicic acid or silica becomes active. The heat of combination is equal to that of nitric acid, and wherever this silicic acid comes in contact with a carbonate it replaces the carbonic acid, forming first the various lime silicates, wollastonite, garnet, epidote and so forth, but later, if the process is continued, sending the bases out in solution and entirely replacing the original compound. The heat-equivalent of all these reactions can be worked out, and in the near future it will be possible, if the history of a piece of metamorphic rock is known, to say that it has given out or absorbed so many calories.

The important fact to observe is that chemical reactions may add to or subtract from the heat of the earth's crust. Generally it may be stated that at great depths the reactions cause diminution of temperature, whereas nearer the surface they are of such a nature that they cause rise of temperature. Every reaction has its own heat equivalent, but it may be safely stated that the majority of heat producing reactions stop at five miles depth in the earth's crust, and that the nearer the surface the greater the number of such reactions. From which it follows that rocks once deeply buried, but now uncovered, are rocks such as have been formed under conditions of heat absorption, and we arrive at the apparent paradox that the fundamental granite and gneiss was melted under conditions of great cold. It is impossible in a paper of this nature to go over all the reasons which make such a fact extremely probable; suffice it here to call to mind that the liquid condition of a substance means that the mass offers no resistance to distortion; hence under enormous pressures it is quite possible to liquefy a solid, such as granite, in much the same way as one can cause lead to flow under pressure†, and in that case, the molecules having the mobility of that of a liquid, will cause the granite to have all the features of a rock crystallized from igneous fusion. From field evidence of the contact of granite and slate, for instance, it is abundantly clear that the rock cannot have been at the temperature necessary to cause it to melt under atmospheric pressure; in the classical examples at Huelgoat in the department of Finisterre, in Brittany, the Silurian slates on the west of the granite are entirely unaltered, though on the east side they have suffered extreme metamorphism, proving that it is not the heat of the granite that has to do with the metamorphism, but rather the pressure which happened to be concentrated on only one side of the granite.

Turning now to the heating effect of radium, we have the work of Joly in the Simplon and St. Gothard rocks to guide us.

In the St. Gothard tunnel, Stapff observed in the central portions temperatures which worked out at a gradient of 46.6 meters (152.8 feet), for 1 deg. C. (33.8 deg. F.), with small irregularities, which he attributed to cold springs and the decomposition of the rock. At the north end, where the tunnel pierces the granite of the Finsteraarhorn massif, there is a rise of temperature sufficient to make the gradient 20.9 meters (68.6 feet) for every 1 deg. C. Stapff explained the last rapid increase by imagining that the granite retained some of the original heat of its molten condition, but Prestwich, on the other hand, preferred to look upon it as the result of mechanical actions which had comparatively recently been in progress, and to which the upheaval of the Alps was due. In the more recently bored Simplon tunnel, Stapff, basing his estimates on the experience obtained in the St. Gothard, predicted a maximum temperature of 47 deg. C. (116.6 deg. F.), while others predicted much lower ones. The actual temperatures observed, however, rose to the north end to 55 deg. C. (131 deg. F.), and caused immense difficulties in ventilation and working. This unexpected high temperature was believed by Fox to be due to proximity to volcanic rocks, but nothing of the sort has been noticed on the surface. This fact nevertheless shows how impossible it is to estimate increase of temperature in the earth's crust; in the Simplon case the excess of heat almost stopped the working, whereas the deep levels of the Witwatersrand, which should be almost unbearably hot if the established temperature gradients existed in nature, are comparatively cool.

Joly investigated the Simplon and St. Gothard rocks with a view to ascertaining their radium contents, and found that the amount of radium contained in the various types encountered corresponded in a remarkable way with the temperature gradients, so that in the high gradient region of the St. Gothard the amount

* South African Journal of Science.

† The parallel of granite and lead under pressure is not strictly a true one, since the granite becomes molten through the solvent action of water, which, under high pressures, dissolves silicates.

was 14.1 billionths of a gramme per gramme of rock, whereas in the low gradient region it fell to 3.3 billionths. In regard to the temperatures of the two tunnels, the following tables show the same correspondence:—

Simplon Tunnel, amount of radium per gramme of rock substance in billionths of a gramme:

Jurassic and Triassic altered sediments	6.4
Crystalline schists, partly Jurassic and Triassic and partly Archæan	7.3
Monte Leone gneiss and primitive gneiss	6.3
Schistose gneiss	6.5
Antigorio gneiss	6.8
Mean for all rocks	7.1

St. Gothard Tunnel, amount of radium per gramme of rock substance in billionths of a gramme:

Granite of Finsteraarhorn	7.7
Maximum	14.1
Usernmulde	4.9
St. Gothard massif	3.9
Tessin mulde	3.4
Mean in Central Section	3.3

From Joly's figures there can be no doubt left in one's mind that radium has at any rate a very great influence on the temperature observed in rocks, if it is not entirely responsible for all the heat in the earth's crust. But the work of Strutt, who initiated this line of research, is still more positive. The following table is taken from his work on the distribution of radium in the earth's crust and on the earth's internal heat:

Rock.	Locality.	Radium in Billionths of a Gramme per Gramme of Rock Substance.
Granite	Rhodesia	9.56
Granite	Cape of Good Hope	7.15
Granite	Shap Fell	6.65
Granite	Isle of Rum	6.76
Olivine basalt	Skye	1.32
Basalt	Victoria Falls	1.26
Basalt	Ovifak, Greenland	0.613
Dolerite	Isle of Canna	1.24
Dunite	Loch Scaivig	0.664
Stony meteorite	Dhurmsala	1.12
Iron meteorite	Three specimens	....
Native iron	Disco, Greenland	0.424

The general result of the analysis of the 33 specimens tested is that the radium content is higher in silicious than in basic rocks and that meteoric iron is free of radium. Assuming that the rate of increase observed in the crust of the earth is 1 deg. F. for every 42.4 feet, according to Prestwich's mean, then if all the heat were solely produced by radium contained in the earth, the amount would be .175 billionths of a gramme per gramme of earth substance, taking it all through. All igneous rocks, however, contain far more than this; the poorest of all, the Greenland basalt, contains 10 times as much and an average rock 50 to 60 times as much.

If then the earth cannot contain on an average more than .175 billionths of a gramme per gramme of earth substance and that 5 billionths is a representative value for rocks in the crust of the earth, then not more than 1/30 of the earth's volume can consist of material similar to that encountered on the surface. This would give a depth of rock crust of about 45 miles, assuming a total absence of radio-active material within.

Suppose, further, that all the heat in the earth's crust is produced by radium, then the temperature at the base of the 45 miles will be 1530 deg. C. (2786 deg. F.). Radium has been tested up to a temperature of 1200 deg. C. (2192 deg. F.), at which point no diminution of its properties was observed, so that there is no reason to suppose that the temperature at the base of the rocky crust would interfere with the emanation of heat. Remembering, however, that the fundamental rock of the earth's crust is granite, the radium content 5 is probably far too low; considering also the contributory effects of the chemical reactions, the depth of the radium-containing crust can be halved or at any rate reduced to Milne's estimate of 30 miles. There is a further consideration not contemplated by Strutt, namely; the probability that the radium is concentrated near the surface of the earth and the heating effects therefore would be confined to a zone near the surface.

These researches then lead us to the conclusion that the earth consists of a self-heating crust resting upon a solid nucleus. Is there any reason to believe that this central nucleus is hot or cold? Until very good evidence is adduced to the contrary the earth centrosphere must be regarded as having the temperature of outer space, that is—273 deg. C. (—459.4 deg. F.), plus any heat that may have radiated out into it from the surface layer. For consider how this earth's center has been formed. Meteorites large and small have come together and have been consolidated by mutual gravitation; heat by impact of new meteorites has been generated and the whole has swung round for immeasurable time in an extremely cold medium. When the earth was small, or even as large as the moon, the radiation of heat into space would have been rapid enough to cool down the whole to the temperature of outer space. Only later, when water became abundant on the surface and the outer rocks became disintegrated, changed by chemical processes, enriched by the concentration of radio-active substances through solution and deposition and distorted by earth folds and quakes, could the internal generation of heat keep pace with the radiation of heat into space and the crust of the earth could thus become habitable. If we accept Prof. Chamberlin's planetismal hypothesis, then it seems inevitable that we must regard the earth's center as a cold body like that of the moon. In a small body, a cold nucleus surrounded by a hot surface would gradually assume the temperature of the surface, but in a vast body like the earth the penetration of the heat into the interior is stopped by absorption in chemical and physical changes near the base of the crust, and at most the temperature cannot be in excess of that existing in the surface layer i. e., 1530 deg. C. (2786 deg. F.).

The production of molten lava in volcanoes is to be attributed to local causes in the outer 10 or 12 miles of the crust; where movement and consequent frictional heat is being developed; as this heat is brought in lava streams and hot springs to the surface and there dissipated into space, the melting of the rock under these circumstances does not add to the general body heat of the earth. Or to look at the question in another way; since the heating effects in the earth's crust in the end can be traced to the agency of water, so we can state roughly that the limit of warmth in the earth is determined by the percolation of water; as granite has been formed with the help of water we can define this limit of heat at that depth to which the earth's substance has the elasticity of normal rocky substances, namely: 30 miles.

In other words, the temperature increment in the earth's crust will increase as we go downward till a limit is reached, and beyond that, there will be a decrease. Is there good evidence for this theoretical deduction in actual fact? South Africa is peculiarly well situated to answer this question. From the recent work of Jean's, it is found that the earth is pear-shaped with the stalk end in Africa and the blunt end in the Pacific. The reason for this shape is that nowhere else in the globe are sedimentary rocks of post-Archæan age so thinly developed; for immense periods the Continent of Africa has been practically uncovered by the sea, and as a consequence, where the rest of the crust has been burdened by thicknesses of strata representing billions of tons, Africa has stood free. Hence, whereas the rest of the globe has been depressed, Africa has been bulged out beyond the limits of the sphere.

In piercing the rocks in Africa we therefore penetrate deeper into the earth's interior than in any other part of the globe, and we find that the temperature increment, instead of being anything like the average of 1 deg. F. for every 60 feet, is 1 deg. F. for every 225 feet on the Rand.

There are of course other areas of low temperature increment in the globe, such as the granite area of Minas Geraes in Brazil, also a region of granite and gneiss thinly covered with sediments, but nowhere else than in Africa is such a vast area of low temperature increment to be reckoned on. If the height of the bulge of Africa above the spherical surface be taken at five miles this would mean that in five miles the temperature increment has fallen from 1 deg. F. for every 60 feet to 1 deg. F. in 225 feet.

It is, however, impossible to reduce the observations to scale in this way; a contemplation of the rates of increase at various places given in any of the lists makes is quite obvious that no prediction of temperature increase at one place can be made from observations at another, as we have seen was done with unfortunate consequences in the case of the Simplon tunnel; in the British Isles alone the temperature increment varies from 1 deg. F. for every 34 feet to 1 deg. F. for every 130 feet; but, taking all the variations into account, there is sufficient evidence from the observations to bear out the contention that the nearer the interior of the globe the less is the temperature increase for equal distances. This has been long recognized and regarded as an insoluble enigma, but in the light of modern geological thought it is not only not an enigma but a necessary consequence.

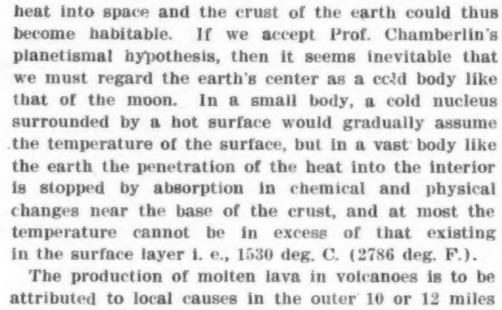
The belief in a hot interior of the globe has so possessed the minds of people, that when deep level mining is proposed, the public still cling to the belief that it must be impossible because their geological text books say that at such depths the temperature would be prohibitive to working. I venture to trust, therefore, that a more widespread knowledge of Chamberlin's planetismal hypothesis and the developments that have appeared since its publication are not only of academic interest, but have an important bearing on the economic welfare of this country. I have, I am afraid, outlined a number of contentious arguments, but the intention of this paper is more to call attention to the trend of modern investigation in geology than to prove each step, and I have elsewhere dealt with the whole subject *in extenso*.

APPARATUS TO ILLUSTRATE EARTH-INDUCTION, AND THE PRINCIPLE OF THE SIMPLE DYNAMO AND MOTOR.*

By Henry S. Curtis.

The apparatus consists of an armature shaped as shown in the figure, about three inches long and one and one-half inches wide. It is fixed to a four-inch length of steel knitting needle, which serves as an axle. This axle rests in two holes bored in metal uprights, so that the axle is about four inches above the base of the apparatus. The armature is made of soft sheet iron, and is wound with about six layers of No. 22 insulated copper wire, and the terminals of the wire are soldered to the two sections of a one-inch long brass tube, slit on both sides, and insulated, so as to serve as a commutator. The brass tube is mounted on a cylinder of cork, through which the axle passes, the diameter of the tube being one-fourth inch. It is bound to the cork cylinder with waxed thread. The armature and uprights are mounted on a wooden base, about six inches square, and at the two sides, so that the armature may revolve between, with a leeway of about an inch, are two wooden uprights with slots cut facing the armature, so that magnets may be inserted, and act as field magnets to the revolving armature. On these uprights are set small wooden cross pieces pointing in toward the commutator, and carrying straight pieces of copper wire. These wooden cross pieces are pivoted each on a single screw, so that the copper wire may be brought in contact with the commutator, and act as brushes. The outer ends of these wires lead to binding posts screwed into the outer ends of the cross pieces. The apparatus is very simple, and the cost of the material is slight.

In the original apparatus the core of the armature



ARRANGEMENT OF ARMATURE PARTS.

was made of a single thickness of soft sheet iron, cut out with shears, but I believe several layers would give a better effect. The diagram will make clear the general arrangement of parts.

USE OF THE APPARATUS.

The apparatus may be made to show the following phenomena very nicely:

First. Earth-induction. If the apparatus be connected to a galvanometer (an ordinary laboratory astatic galvanometer is sufficiently sensitive) the current induced when the armature is spun around by hand in the earth's field may be plainly shown. A difference of deflection also may be noted, if the apparatus is shifted, so that the plane of the rotating armature is at different angles to the earth's lines of force.

Second. The principle of the dynamo may be shown by inserting the two bar magnets in the slots, with opposite poles facing the armature. The galvanometer will show currents opposite in direction, when the armature is rotating first in one direction and then in the other, or when the polarity of the field is reversed. Indeed, by holding one magnet in the hand, at a distance of several inches from the apparatus, a marked deflection of the galvanometer may be obtained.

Third. The apparatus illustrates very well the principle of the motor by connecting several dry cells in place of the galvanometer. The motor may be reversed by reversing the polarity of the field or the direction of the current.

* School Science and Mathematics.

To blacken light woods, make a preparation of an ounce of borax, dissolved in a quart of water, with two ounces of shellac. The liquid is then to be boiled until a perfect solution is obtained, then stir in two teaspoonfuls of glycerine, and complete by adding a sufficiency of soluble aniline black to completely darken the liquid, which will now be ready for use.

HOW TO MAKE A SHOCKING COIL.

SIMPLE INSTRUCTIONS FOR AMATEURS.

Most amateurs in electricity like to make a shocking coil at some time or another, chiefly at an early stage of their training. The reason for this is, no doubt, the fact of their being able to feel the force of the electric current. The principal point in making a shocking coil is the winding of the primary and secondary coils round the center core, and amateurs must first thoroughly grasp the method of winding.

Starting with the base of the instrument, this should be of hard wood, preferably mahogany, planed smooth and finished to 5 inches wide, 12 inches long and ½ inch thick. For ornamental purposes a molding should be worked all round the top edge.

The core should be made of soft iron wires of No. B. W. G. (neatly made up in the form of a bundle), each wire being cut 4½ inches long. These wires should be inserted in a thin brass tube about ½ inch shorter in length than the wire, and ½ inch in diameter, as in Fig. 1.

The best way to do this is to buy a coil of the wire and cut off a number of 4½ inch lengths. Fill the tube

Fig. 1.

with these lengths, finally pushing one or two right in the center so as to make the core very tight.

Next take some soft fine wire and bind the projecting end of the wires tightly, at the same time pulling the core carefully out and binding until all the wires are covered with the outer binding, as in Fig. 2. This bound core must now be placed in a fire till it is red hot, and then left there till the fire gradually dies out, after which the bundle can be removed. This process softens the core and renders it better fitted for the purpose for which it will be used. The binding wire must then be unwound a little at each end (about ½ inch), and the ends dipped in fluid solder. When this has set, all the wire must be unwound, leaving the soft iron core ready for use. It may possibly be found that the ends require a little filing in order to make the tube fit tightly.

The tube in which the core ultimately works (see *A* Figs. 3 and 4) is an ordinary cardboard one, such as is sold at stationers. The core must fit this tube tightly, and project about ¼ inch at one end.

The bobbin heads, *B* should be of hard wood, ½ or ⅝ inch thick, and about 2½ inches square. They can be fixed to the base in any convenient manner, the form shown in Fig. 3 being perhaps the strongest. Each head must have a central hole to fit the tube, leaving the free end of the core protruding as shown. The top of the head at this part must have two terminals, *X* and *Y* (see plan, Fig. 5), to ultimately hold the ends of the primary windings.

The "primary" winding can now be attempted. This is the term given to the first winding next to the core, and the wire used for this is much thicker than the outer or "secondary" winding. This wire is

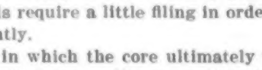


Fig. 2.

sold by the pound, and about five or six ounces of No. 20 B. W. G. cotton-covered wire will be required so as to make four layers. It is best to soak the wire in melted paraffin wax before use. Another way is to apply the wax thoroughly to each layer while it is being wound. In starting to wind the wire, a hole should be bored at *C* (Fig. 3), for the commencing end, and another at *D*, for the finished end of the primary wire. It is easier to do the winding before fixing one of the bobbin heads, as several inches can be left at the start and finish for passing through the previously prepared holes in the loose bobbin head.

The wire must be wound evenly and closely, beginning at the free end, then returning to this free and after the second layer has been wound. Do not forget the waxing at each layer, and take care to prevent the last turns in any one layer from sinking down into the space against the bobbin heads. When the primary is wound, cover it with three layers of paraffined paper. The free ends of the wire must now be bared of insulation for about ½ inch, and connected to the terminals (*X* and *Y*, Fig. 5). The secondary coil is made of much finer wire, viz., No. 34, about ½ pound being required, and it should be *silk-covered*. This secondary wiring is wound over the primary coil exactly in the same way as the primary, evenly and closely, and about 6 and 18 inches being brought out at the ends (*F* and *G*, Fig. 3). For a neat finish to the coil, thin green velvet or silk should be covered over the outside of the wire. The wiring takes some time to do neatly, and simple devices (called coil winders) which facilitate this process can be bought.

We now come to the contact breaker, shown to a

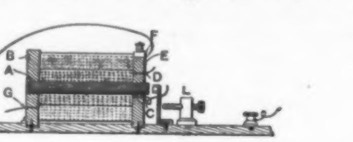


Fig. 3.

larger scale in Fig. 6. This device consists of an upright plate of thin, springy brass, to the top end of which is fixed (by brass rivets) a soft iron cylindrical piece, *J*. The lower end is similarly fixed to a stout piece of brass, *K*, which is secured by brass screws to the baseboard. The hammer piece, *J*, should be fixed so as to normally lie ¼ inch away from the end of the core. *L*, Fig. 3, represents an ordinary screw pillar such as is often used in electric bell work. A platinum foil piece, *M* (see Fig. 6), is soldered to the brass plate, *H*, just where the screw meets it, and a speck of platinum is soldered on the end of the screw. If platinum foil cannot be obtained, then No. 18 B. W. G. platinum can be soldered on and burred over to form a rivet head for the screw to make contact. All the current has to pass through these contacts, so that great care should be taken to make them perfect.

Four terminals (*N*, *O*, *P*, *Q*) are required on the baseboard (see Fig. 5), two (*N* and *O*) for connections to a battery, and two (*P*, *Q*) for the ends of the secondary coil. One of the battery terminals, *O*, is connected to

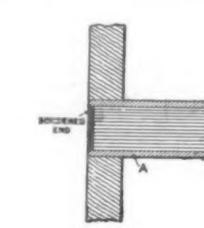


Fig. 4.

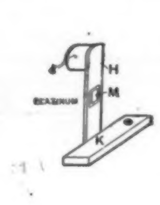


Fig. 6.

the brass terminal, *X*, on top of one of the bobbin heads; the other, *N*, is connected to the foot of the contact pillar, *L*, while another short piece of wire runs from the foot of the plate, *K*, to the terminal, *Y*. The apparatus is now complete with the exception of a couple of handles connected to *P* and *Q*, by means of flexible wires, as shown in Fig 7 and a battery. With respect to the strength of battery necessary for such a coil, it may be mentioned that with one bichromate or dry cell, a not very powerful shock can be felt. By adding fresh cells, the strength of the shocks will be very marked. If dry cells are used, do not use them for long at one time, whilst if bichromate cells are employed take care to lift the metals from the solution when the coil is not in use.

Shocking coils belong to the family of induction coils, which can be roughly divided into two classes: those for shocking or medical purposes, and those for supplying sparks. Shocking coils do not require such care as sparking coils, the latter calling for greater precautions for insulation.

The cores of all shocking coils are made of iron (chiefly wires), and the method of mounting is precisely the same. The primary coils must always be soaked in melted wax as previously explained, solely because the insulation is rather poor. If cotton-covered

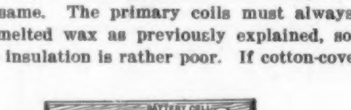


Fig. 5.

wire is used for the secondary wire, it must also be covered with wax, but this is not necessary when silk-covered wire is employed.

The paraffin wax should be hard, clear and pale, and, if expense is not objected to, pure beeswax will answer, taking care not to burn the wax when melting it. A good plan is to melt it in boiling water, glue-pot fashion. No provision is made in the foregoing coil for regulating the shock other than by the battery, and if such is required, then the coil should be modified. Regulation can be effected by sliding the secondary coil over the primary, or by having a brass tube covering the core between the paper or cardboard tube. Fig. 8 shows the latter arrangement. Here it will be seen that the cardboard tube, *A*, is much larger, and provided with an inside collar, *A1*. A brass tube, *A2*, fits over the wires, with a brass handle for withdrawing. This brass regulation tube slides over the core and checks the current, the greatest effect of the current being felt when the core is fully uncovered—that is, when the tube is fully drawn out. It is thus advisable to employ the original brass tube. By adopting such a regulating device, the apparatus becomes a sort of medical coil.

In the coil illustrated here it is not necessary to employ the terminals *X*, and *Y* at all; the wires may be run direct to contact the breaker and battery terminal. The use of the terminals, however, prevents any drag on the coil itself.

In our drawings the wires are shown loosely, but in

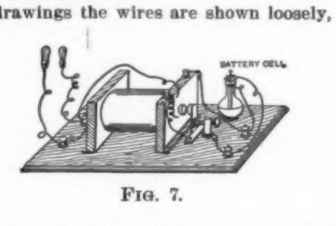


Fig. 7.

the actual apparatus they should be carefully hidden out of sight on the underside of the baseboard.—Home Handicrafts.

SOME BRILLIANT EXAMPLES OF INEFFICIENCY.

By Harrington Emerson.

The efficiency engineer meets everywhere the inefficiencies, losses, ravages, disasters, material and moral, always latent, often active in wrong organization. To illustrate by instance from experience:

The able president of a two-hundred-million-dollar corporation, hearing that piece work resulted in greater output than day work, ordered piece rates put in and made the basis of remuneration on a few days' notice. A disastrous strike followed, costing the corporation $2,000,000, the community being made to suffer from violence of all kinds by strikers and their sympathizers, by officials and their hirelings. This president would not have presumed to design a steam engine, perhaps not have presumed without advice to select a typewriter; yet he rashly acted on two of the most delicate problems that confront any modern corporation, *wages* and *efficiency reward*. He did not know that efficiency reward ought to be preceded by the careful, systematic, and expert application of eleven other principles, of which "Wages" is a minor element of one; he did not know that the eleven anterior principles were largely lacking in application in his company, and that conditions were not ripe for any form of efficiency reward; he did not know that

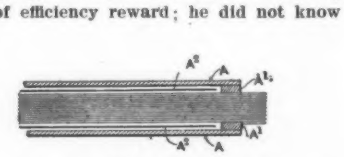


Fig. 8.

even if his company had been fitted to adopt the principle of efficiency reward, it remained a momentous question as to what form should be used, piece rates being probably the last that a competent expert would recommend. He was not to blame. He had to make a decision, and he did not have an organization around him, over him, under him, that automatically prevented this mistake, equally disastrous to his company, to his employees, and to himself.

The general superintendent of one of the largest American industrial plants, tremendously successful through his great genius, power, ability, told me with pride that for five months he had refused to allow any shop tools or supplies to be bought. He boasted that a smith foreman, failing to secure on requisition flatter steel, had made flatters out of Krupp steel tires which he appropriated for this purpose. The tool account came down, it is true, but at what cost in man-wasted time with smooth files, and all other man-supply deficiencies—in diminished output from machine-wasted time due to defective belts and all other machine-supply deficiencies?

Industrial arbitrariness by the superintendent, delegated and usurped power in the foreman, anarchy all along the line!—Engineering Magazine.

STEAM TURBINES.—I.*

THEIR DEVELOPMENT DURING THE LAST TWENTY-FIVE YEARS.

BY GERALD STONEY, B.E., M.INST.C.E., M.I.E.E.

In considering the subject of steam turbines and their development during the last twenty-five years, it may be worth while considering the question of prime movers in general.

Man has from the earliest times sought to utilize other powers to supplement his own, and to help him in his work. In the Bible, we read in Genesis, "Jacob put his sons and wives upon camels," and the use of horses and other animals to help man by drawing loads, or carrying him, dates from the earliest times; but the use of steam in a practical form dates from about the middle of the eighteenth century. The most notable of the early engines was Newcomen's, in which steam under low pressure was admitted under a piston which rose, doing little or no work, and then, when the steam was condensed by a water jet in the cylinder, the vacuum formed sucked the piston down. The top of the cylinder was generally open to the air, and water was supplied above the piston to keep it air tight. These atmospheric engines were largely used for pumping, and the coal consumption was somewhere about 20 pounds per horse-power hour.

James Watt, about the middle of the eighteenth century, saw that this large coal consumption was due, in a great degree, to cylinder condensation, and after trying the effect of lining the cylinders with wood to form a non-conducting lining, he hit upon the happy idea of carrying on the condensation of the steam, not in the cylinder itself, but in a separate vessel. This was, in fact, the invention of the separate condenser. At the same time, the cylinder was closed in so that there was steam, not air, above the piston. These improvements reduced the coal consumption to somewhere about one-fourth to one-third of what it had been before, or to between 5 and 7 pounds per horse-power hour, and at once enabled the steam engine to take its place among the great prime movers of the world.

This Watt engine remained, in principle, without improvements except in detail until the middle of the last century, when owing to the gradual rise of steam pressure, and consequent extra expansion, compound engines began to be introduced. This was also helped at sea by the introduction of the surface condenser, without which, giving as it does fresh water to the boilers, it was impossible to use above 25 or 30 pounds steam pressure. As engineers gradually got better materials, and more experience was gained, steam pressure increased, and the triple and finally the quadruple expansion engines were introduced with the object of increasing the expansion ratio. It has, however, been found that unless there is a steam pressure of about 7 pounds per square inch upon the low pressure piston, the size and cost of the low pressure cylinder become excessive, and therefore the reciprocating engine is limited practically to about 16 expansions, and this is apparently about the limit of efficiency of reciprocating engines. With modern steam pressures, is not much, but a considerably greater gain is easily seen to be made by going to lower pressures, that is, utilizing higher vacua, and this is what the steam turbine enables one to do. It therefore has always seemed to me that the greatest step in the improvement of the steam engine which has taken place since

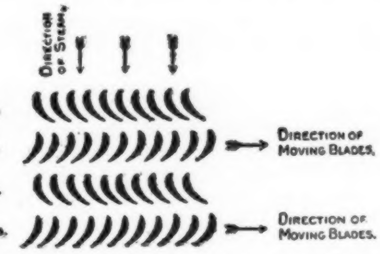


Fig. 1.—DIAGRAM SHOWING ARRANGEMENT OF BLADES.

Watt's time, and Watt's invention of the separate condenser, has been the introduction of the steam turbine in a practical form.

It has been found that in the reciprocating engine there is little use, considering the temperature at which the feed water is returned to the boiler, in going to a better vacuum than 25 inches. With the steam turbine, vacua of 28 inches or 29 inches, or absolute pressures of from ¾ to ½ pound per square inch, can be easily utilized, as the difficulty of dealing with large volumes of steam does not occur in the case of the steam turbine as in the case of the reciprocating engine, and it has been found that with the steam turbine the gain due to vacuum goes steadily on up to the highest attainable vacua. Between 25 inches and 20 inches, or 20 inches and 27 inches, there is a gain of about 4 per cent; a further gain of 5 per cent is made with the vacuum increased to 28 inches, and a still further gain of 6 to 7 per cent when it is increased to 29 inches.

This is more easily understood if we consider that the theoretical power to be derived from the steam is almost proportional to the logarithm of the expansions, and thus practically the same power can be obtained working from 400 pounds to 1 pound absolute, or 20 inches vacuum, as from 200 pounds to one-half pound, or 29 inches vacuum. In each case there are 400 expansions by pressure, and in each case the theoretical consumption of steam by Clausius' cycle would be about 9.3 pounds per kilowatt hour. With 150 deg. F. superheat this would come down to 8.7 pounds, and under the conditions of 200 pounds pressure and 29 inches vacuum with 150 deg. F. superheat, 13.2 pounds per kilowatt hour has actually been obtained with an overall efficiency, including the alternator, of about 66 per cent, or 71½ per cent on the turbine shaft, allowing for the electrical losses. Professor Ewing, in his book on "The Steam Engine," gives a list of principal results obtained from condensing reciprocating engines, and in no case does the ratio of the consumption of steam by Clausius' cycle, compared with that used per indicated horse-power, exceed 64 per cent. As the ratio of brake horse-power to indicated horse-power is never more than 99 per cent, this means an efficiency at the engine shaft of not more than 58 per cent. When it is remembered that the figure obtained in the case of the turbine was 71 per cent, and further that the reciprocating engine is unable to take advantage of high vacua, it is easily seen where the advantage of the turbine, especially in large sizes, comes in.

In all machinery with reciprocating parts heavy foundations are required, and in many cases the trouble due to vibration is considerable, especially in the case of quick-running engines. As an example, in 1894 the reciprocating engines at the Manchester-Square Station of the Metropolitan Electric Supply Company caused so much annoyance on account of vibration that the company were threatened with an injunction, and the substitution of turbines for the reciprocating engines saved the station from being shut down. Besides that, especially in large sizes, the cost of repairs and attendance is much less, while the space occupied is only about one-third or one-quarter of that required for reciprocating engines. In very large sizes it has been found practically impossible to make reciprocating engines satisfactory, and it may not, perhaps, be generally known that one of the reasons which led the Cunard Committee to adopt turbines for the great express steamers "Lusitania" and "Mauretania" was the fact that the engineering difficulties of the enormous reciprocating engines required made the problem almost impossible of solution without the use of turbines.

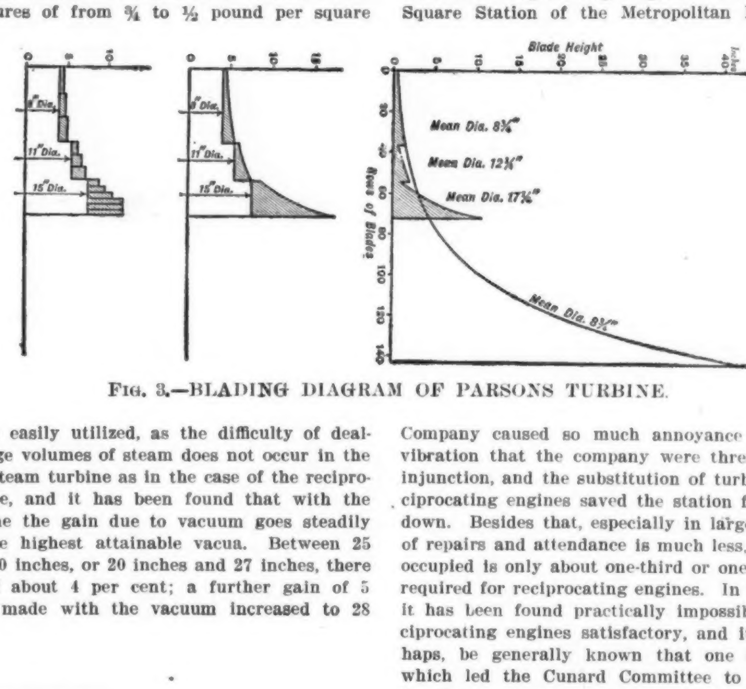


Fig. 3.—BLADING DIAGRAM OF PARSONS TURBINE.

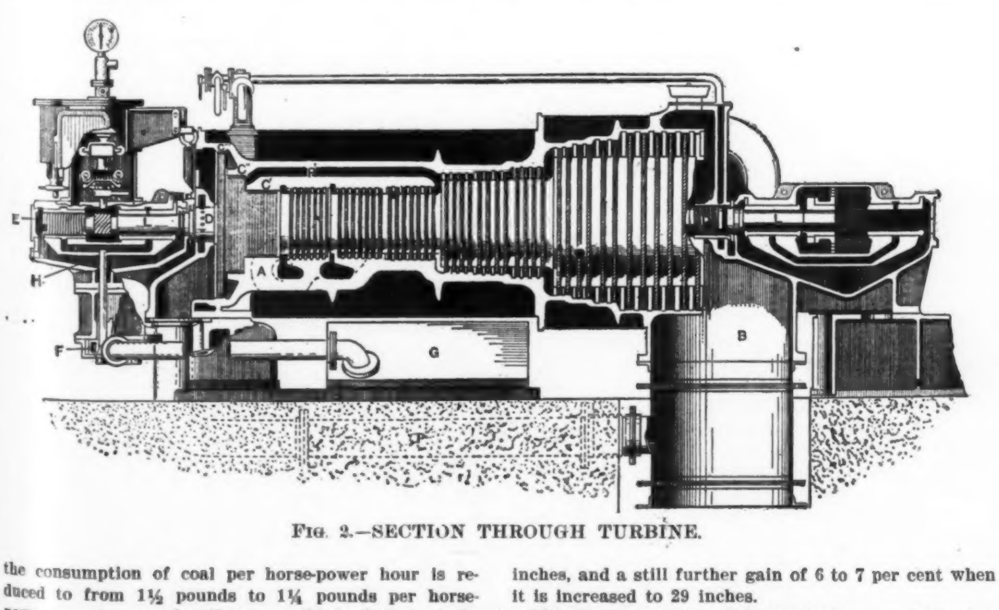


Fig. 2.—SECTION THROUGH TURBINE.

the consumption of coal per horse-power hour is reduced to from 1½ pounds to 1¼ pounds per horse-power or some one-fourth to one-third of that of the fuel consumed in the time of James Watt, and some one-fifteenth of that used in the time of Newcomen.

The gain by going to higher steam pressures than the modern ones of 180 to 200 pounds per square inch

Steam turbines may be divided into two great divisions—single and compound. In the former class there is the De Laval, in which the whole of the expansion is carried out in a single jet impinging on a wheel rotating at a high velocity. In order to get efficiency, the highest possible velocity for the wheel has to be attained, reaching in the larger sizes some 1,200 feet per second, above which it is practically impossible to go on account of the centrifugal forces, and this means a speed of rotation too high for the dynamo or other machine to be driven by it. The result is that gearing has to be used to reduce the speed of rotation, and this limits this class of turbine to small sizes—not, as a rule, exceeding 200 or 300 kilowatts.

The second class is that universally adopted for all large turbines, in which the expansion of the steam is carried out in stages. If the expansion is divided up into a number of steps the velocity of the steam is greatly reduced, and thus not only can the surface velocity of the turbine wheels be reduced but also the speed of revolution, and cutting action of the steam is prevented, for high velocity steam jets are able to cut away the hardest steel. Even yet in some classes of turbines with few stages there is still cutting action on the blades.

The compound turbine naturally divides itself into

* Journal of Society of Arts.

two sub-classes, those in which the expansion of the steam takes place both in the fixed and moving blades, and those in which it takes place in the fixed blades only. Included in the former class is the Parsons, while the latter contains the Rateau, Zoelly, Curtis, and various others. In the Rateau and Zoelly, which strongly resemble one another, the velocity of the steam at each stage is taken up by a single row of blades mounted on a wheel, and in the Curtis by a wheel having two or more rows of moving blades with guide blades between. There are also various combinations of these, especially those with a Curtis high pressure part and a Parsons low pressure, but as yet they have not come largely into use.

And now I may perhaps be allowed to say a few words on the origin of the steam turbine on land, which dates from 1884, when Mr. Parsons made his first turbine of about 10 horse-power.

The first steam turbine Mr. Parsons made is in the South Kensington Museum, close to the Rocket and other historic engines, and Fig. 1 shows two rows of the blading of a Parsons' turbine. The steam enters the fixed blades at the top, and impinges in a series of jets on the moving blades, driving them round as shown by the arrow. Passing through the moving blades the steam issues from them in a series of jets, which by their reaction again help to drive round these moving blades. Then it passes on to the next row of fixed blades, and so on, expanding slightly at each row of blades until it finally reaches the exhaust.

Thus the old Parsons steam turbine consists of two groups of fifteen successive turbine wheels, or rows of blades, on one drum or shaft within a concentric case on the right and left of the steam inlet, the moving blades or vanes being circumferential rows projecting outwardly from the shaft and nearly touching the case, and fixed or guide blades being similarly formed and projecting inwardly from the case, nearly touching the shaft.

A series of turbine wheels on one shaft is thus constituted, each one complete in itself like a parallel flow water turbine, the steam, after performing its work in each turbine, passing on to the next, preserving its longitudinal velocity without shock, gradually falling in pressure on passing through each row of blades, and gradually expanding. Each successive row of blades is slightly larger in passage-way than the preceding, to allow for the increasing bulk of the elastic steam, and thus its velocity of flow is regulated so as to operate with the greatest degree of efficiency on each turbine of the series. All end pressure from the steam is balanced by the two equal series, one on each side of the inlet, and the revolving shaft lies on its bearings, revolving freely without any impressed force except a steady torque urging rotation, the aggregate of the multitude of minute forces of the steam on each blade. But before this could be made a practical success it was necessary to carry out a series of experiments on shafts revolving at very high speeds, and this was done by Mr. Parsons about 1884. It is not possible to run a shaft or spindle in fixed bearings at very high speeds, as owing to the impossibility of making a shaft absolutely true, and of obtaining material of absolute uniform density, such a shaft is always slightly out of truth and balance, and violent vibration and heating of the bearings is set up at such high speeds. This difficulty can, however, be got over by the very beautiful device of allowing a little play in the bearings to compensate for any lack of balance.

Such a bearing consists of a bush in which the spindle revolves, surrounded by three concentric tubes with a slight amount of clearance between each. The small annular spaces between the tubes are filled with a film of oil, and the whole make a flexible bed for the shaft to run in, taking up all vibrations which in turn are damped out by the films of oil.

The steam turbine described constitutes a truly rotary engine, but it had limitations. The comparatively high speed of rotation that was necessary for so small a size of engine as this first example made it difficult to prevent a certain spring or whipping of the shaft, so that considerable clearances were found necessary, and consequently leakage and loss of efficiency resulted. It was, however, perceived that these defects would decrease as the size of the engine was increased, with a corresponding reduction of rotational velocity, and efforts were therefore made towards the construction of engines of larger size, which resulted in 1888, in several turbo-alternators of 120 horse-power being supplied for the generation of current in electric lighting stations, and in 1892, the compound steam turbine was first adapted to work in conjunction with a condenser.

The first condensing turbine was one of 150 horse-power, and at a speed of 4,800 revolutions per minute, drove an alternator of 100 kilowatts output. It was tested by Professor Ewing, and the general result of the trials was to demonstrate that the condensing steam turbine was an exceptionally economical heat engine.

With a steam pressure of 100 pounds, the steam being moderately superheated, and a vacuum of 27 inches Mercury, a consumption of 27 pounds per kilowatt hour, which is equivalent to about 16 pounds of steam per indicated horse-power, was obtained. The result marked an era in the development of the steam turbine, and opened for it a wide field, including some of the chief applications of motive power from steam. As a result, at about this period turbine alternators of the condensing type were placed in Newcastle, Cambridge and Scarborough Electric Supply Stations. These steam turbines were of the radial flow type, which had been reluctantly adopted in 1891 on account of the temporary loss of the patents, but on the recovery of these in 1894 the parallel flow type was reverted to with considerable improvements in design, calculated both to increase the economy and decrease the cost of manufacture. Instead of the steam entering at the center and expanding both ways, one set of blades was replaced by a set of dummy pistons in which a grooved piston or dummy on the spindle ran close to, but not in contact with, corresponding grooves in the cylinder, thus making a practically steam tight and yet frictionless joint. At the same time the system of blading was greatly improved, giving a more perfect form of blade with much greater mechanical strength than in the original formation.

The steam turbine which is shown in section in Fig. 2 consists of a cylindrical case with rows of inwardly projecting blades. The steam enters at *A* on the lower half of the cylinder, thus leaving the upper half quite clear of steam pipes and all obstructions and facilitating dismantling. It then passes successively through the different rows of fixed and moving blades, as explained above, and leaves the cylinder through the exhaust pipe, *B*. In order to give increased passage way for the steam as it expands, the shaft is made with three steps of different diameter, the height of the blades being also increased. The steam, in addition to its rotational force, exerts a pressure endways along the shaft on the surface of the blades and the shoulders of the shaft. This is balanced by the dummy pistons $C'\ C''\ C'''$, as shown in the section. They are made of diameter corresponding to the different parts of the turbine they balance, and are supplied with the corresponding steam pressure through the pipes $P'\ P''$. The shaft thus runs in complete balance endways, and can be moved backwards and forwards with a light lever, even when the turbine is running under full load. In order to prevent steam leakage, grooves are turned in these pistons, into which project, without, however, touching the moving parts, suitably shaped strips of brass caulked into grooves in the cylinder. The whole forms a labyrinthine passage offering great resistance to the escape of the steam, most of which is carried round and round by the skin friction of the dummy pistons, producing a most effective screen against leakage. The two glands *D*, where the shaft leaves the turbine casing, are constructed in precisely the same manner. The steam for packing them is obtained from the exhaust of the steam relay, a live steam connection being fitted for use before starting up. An ejector is also fitted to draw excess steam away from the glands. The coupling between the turbine and generator is of the flexible claw type, to allow for slight difference in alignment of the two portions of the plant. The thrust-block, *E*, at the end of the turbine shaft, merely keeps it in place with the right clearance between the fixed and moving parts of the glands and dummies, and adjustment is made in a few minutes with a small liner behind the thrust-block.

The first large turbines of this improved type were of 350 kilowatts output, and were placed in the Manchester Square Station, in London, of the Metropolitan Electric Supply Company. This station was, at the time, threatened with an injunction for vibration caused by the reciprocating engines used there, and the substitution of the turbines proved entirely satisfactory, both to the users and to the company.

In 1900, two 1,000 kilowatt turbo alternators were supplied to the City of Elberfield in Germany, which were tested by a committee of German experts on behalf of the city, and showed a steam consumption of 18.22 pounds per kilowatt hour at full load. This result has been surpassed in many cases, notably in the case of the 5,000 kilowatt plants for the Carville Electric Power Station, with which a consumption of 13.2 pounds of steam per kilowatt hour was obtained. Within the last twelve years the output of the Parsons steam turbine has gone up by leaps and bounds, until there are now on land about 2,500,000 horse-power of the Parsons steam turbine at work and on order. Practically the whole of the great power distribution scheme in the North-East of England at Newcastle is supplied with these steam turbines. This not only supplies electricity for lighting to the district around Newcastle, but also the whole of the power to many works, shipyards, and factories, besides the electrification of the Tynemouth lines of the North-Eastern Railway. In the power stations supplying that district there are erected—besides smaller ones—eight turbines of 5,000 kilowatts each, the latter only taking 13.2 pounds of steam per kilowatt hour at full load.

In the Rateau and Zoelly types of turbine (which have been developed chiefly on the Continent), unlike the Parsons, in which expansion takes place both in the fixed and moving blades, the whole of the expansion is in the fixed blades, the moving ones being cup-shaped so as to turn the steam and make it give up its energy without altering its velocity while passing through them. The fixed blades are in a series of diaphragms in a cylinder, with a shaft passing through holes at their center, which shaft carries a series of disks having cup-shaped blades on their circumference. Where the shaft passes through the diaphragms there are suitable glands so as to minimize the leakage of steam as much as possible; and, in order to get a good height of blade, the fixed or guide blades, especially at the high pressure end, only extend to a portion of the circumference. As a rule, all the disks are approximately of the same diameter, expansion of the steam being allowed for by both increasing the height of blade and also increasing the widths of the sectors of blades admitting to the revolving disks.

The Curtis turbine, which was originated in America, is of a similar construction of diaphragms, carrying sectors of fixed blades with revolving disks between, but these disks carry instead of one row of blades, two, three, and sometimes four rows with fixed blades between, each row taking up a portion of the velocity of the steam and delivering it to the next row of guide blades at reduced velocity; and when its energy has become exhausted, it is delivered to the next diaphragm, where the drop of pressure enables it again to act on another set of moving and guide blades, and so on until the exhaust is reached.

And now as to the theoretical aspects of the question. Some sixty to seventy years ago the thermodynamic theory of steam was worked out by Carnot, Regnault, Clausius, Rankine, Kelvin, and others, and it was shown that under given conditions of superheat, steam pressure, and vacuum, it was not possible to get more than the amount of power out of the steam as expressed by the cycle which was worked out almost simultaneously by Rankine and Clausius. It is, then, the object of the turbine designer to obtain a result as close as possible to the result which should be obtained according to the above cycle. In this connection it is necessary to have the ratio of the steam passing through the blades the best in relation to the velocity of the blades, and experience has shown that in the Parsons type of turbine this is best when the velocity of the steam is somewhere about double the velocity of the blades, and in the Rateau a little over one-third.

Now the velocity of the steam depends on the drop in pressure between one row of blades and the next, and it can be shown that $v^2 = 2\,g\,H\,\dfrac{dp}{p}$ where g = gravity, H is the homogeneous head of steam which is about 63,000 feet for high pressure steam and about 45,000 feet for steam at atmospheric pressure, p is the absolute pressure at any row of blades, and dp is the drop of pressure between one row of blades and the next, and therefore $\dfrac{dp}{p}$ is the amount of expansion that takes place in any row of blades.

Take as an example, a Parsons turbine, as shown in Fig. 3, which is the blading diagram for a 500 kilowatts turbine for 3,000 revolutions per minute, and 150 pounds pressure, with a vacuum of 28 inches. If we assume that the turbine is of the same diameter throughout, it is easily seen that since the speed of the blades is constant, in order to make the velocity ratio between the steam and the blades constant, the velocity of the steam through the blades must be constant, and as the steam at each row expands by the amount $\dfrac{dp}{p}$ it is evident that each row must have larger openings than the one before by the amount $\dfrac{dp}{p}$, and also that this ratio $\dfrac{dp}{p}$ is a constant throughout the turbine on the assumption that H is constant, which is approximately the case, and for a preliminary consideration may be assumed.

From the equation $v^2 = 2\,g\,H\,\dfrac{dp}{p}$ the velocity of the steam can be calculated at any point along the turbine, and from this and the area through the blades the quantity of steam used per hour can be calculated. In taking the area of the blades it is necessary, not only to take the actual area through the blades, but also that of the clearance space above them, and further to the quantity thus calculated there has to be added the leakage through the dummies, and also if steam packed glands are used, the quantity of steam required to pack these glands.

Both these items, especially the latter, are small ones, but when all these allowances are made it is found that within errors of observation the quantity of steam used by a turbine is the calculated one. It is thus easy to calculate the quantity of steam used

by a turbine, but the horse-power it will produce is another question, and in many cases, especially in new types of turbine where the steam consumption per kilowatt hour was uncertain and a considerable margin was left, it was found that the steam pressures required to give the rated output were considerably lower than was anticipated.

The fact that the steam consumption of a turbine so nearly agrees with theory proves that the velocity of steam through the blades must very closely approach the theoretical, and in fact, unless this was the case, it would be impossible to get from turbines the high efficiencies that are obtained. We therefore have a turbine consisting of a drum with blades gradually increasing in height according to what is known as a logarithmic law, that is, each row of blades is $\frac{dp}{p}$ higher than the preceding one.

Now since, in an ordinary turbine working from say 150 pounds steam pressure down to a pressure of one pound absolute, or a vacuum of 28 inches, there are about 150 expansions by pressure—or, say, 100 expansions by volume—we require the blades at the low pressure end 100 times as long as the high pressure end, so that it will easily be seen that the blades at the low pressure end would be so long as to be impossible to put on the spindle. The device, therefore, is adopted of increasing the diameter towards the low pressure end (see Fig. 3), and, since an increase of diameter also increases not only the circumference but also the velocity of the blades, it is easily seen that the height of blade will vary inversely as the square of the diameter; that is, if you double the diameter, you double the velocity of the blades, therefore you double the velocity of the steam, so that you require only half the area through the blades, but since the circumference is doubled you only require blades of one quarter the height. The usual custom in land turbines is to have three drums $\sqrt{2}$ or 1.4 times the diameter of the other, and thus the blades on the second drum are half the height of what they would be if they had been on the diameter of the first drum, and the blades on the last drum one quarter the height of what they would have been if they had been on the diameter of the first drum. This, in the case mentioned above, where there are 100 expansions by volume, reduces the ratio of blade heights from 100 to 25, and by making the blades at the exhaust end of larger opening, so that they have double the capacity for steam of the ordinary blades, the ratio of blade heights is further reduced down to 12½, and this is a very common ratio between the blades at the high pressure and the blades at the low pressure end in ordinary land turbines.

The three drums of the turbine are so proportioned that about a quarter of the power is in the first, a quarter in the second, and half in the third, but this is purely an arbitrary division, and can be varied within wide limits to any extent desired, but in practice it comes out as a very fair compromise between the various conflicting conditions that have to be considered. Small diameters are an advantage, because you get longer blades, but, on the other hand, as we have shown before, the height of the blade varies inversely as the square of the diameter, and it must be further remembered that the number of rows required for a definite expansion also varies inversely as the square of the diameter, and therefore with small diameters you get great length of drum and long blades, and with larger diameters you get short drums and short blades. The first gives you a turbine shaft of great length which is liable to bend and whip, and therefore the clearance over the tops of the blades has to be increased; the latter gives you very short blades, and on account of their shortness the percentage loss by leakage over the top of the blades is large, and the best result is obtained by a happy compromise between the various conflicting conditions. In this relation it is easily seen that for any given number of expansions and revolutions to obtain a given velocity ratio, a certain volume of spindle is necessary, or generally a more convenient way of expressing it is that the product of the number of rows multiplied by the square of the blade velocity gives a constant which, for any given number of expansions gives a certain velocity ratio between the blades and the steam, which may be from 0.4 to 0.6.

The above theory is on the assumption that H is constant, that is, that steam is a perfect gas, which, of course, is not quite true, and therefore, in order to attain accuracy, corrections have to be made for the difference between steam and a perfect gas, but these being of a secondary order, they are as a rule most easily made by considering H to be constant for various portions of a turbine separately.

In the above turbine, as I have shown, the theoretical curve for the blades is a logarithmic one, but it is almost impossible in practice to make a spindle and cylinder of logarithmic curves, and therefore the device is adopted of stepping the turbine, and, as shown in Figs. 2 and 3, it will be seen that the blades are stepped so as to approximate closely to a logarithmic curve, each step being made so small that there is no appreciable loss of efficiency due to the varying velocity ratios along the step. Another method of calculating turbines is by the entropy diagram of θ ϕ method, and this leads to exactly the same results as the methods using H, or the homogeneous head of steam, which is given above. Some designers prefer one method, and some the other, but personally I have always preferred what may be called the H method.

Other types of turbines such as the Zoelly, Rateau, and Curtis, can be calculated in the same way, but the velocity ratios to give the best results are different for them, and each type of turbine has to be considered separately on its own merits. In turbines, it is easily seen that for a given size, the lower limit of speed is one in which the blades become so short as to cause excessive leakage, and thus loss of efficiency. On the other hand, the upper limit of speed is one in which it is impossible to get sufficient area through the low pressure blades to give good results, since it is not allowable to stress the drum or disk to which the blades are fastened beyond a certain point, and therefore the surface speed is fixed, and it is also necessary not to stress the blades beyond a certain point, and therefore the maximum height of the blade on the drum or disk is also fixed.

Another thing is that it is found not to be advisable to have the height of blades more than one-fifth to one-quarter of the diameter of the drum to which they are fixed, as otherwise they spread so much at the tips as to become a bad shape.

With these limitations it can be shown that turbines can be constructed of similar dimensions to run at speeds the inverse of those dimensions. Thus, if we take a 1,000 kilowatt turbine, running at 3,000 revolutions per minute, and double the size of it all over, the surface speeds will be the same at 1,500 revolutions per minute, and the stresses on the material of the blades, drum, etc., will be the same. On the other hand, we have double the diameter and double the height of blade, and therefore four times the area for the steam to pass through, with the blades moving at the same velocity, and, as a result, four times the power will be obtained; or our turbine at 1,500 revolutions will give an output of 4,000 kilowatts. This gives the limiting speed for any given turbine, but except in exhaust turbines, which work with steam at atmospheric pressure, and therefore have to deal with great volumes, and also turbine driven blowers which run at an average of about one and a half times the speed of turbines driving alternators and dynamos for similar outputs, this limit is rarely attained.

Now it can be shown that alternators also obey the same rule of varying inversely as the square of the speed, and thus it will be seen that alternators coupled to turbines go up in size together, and that apart from the trouble there is due to being compelled to have an even number of poles, alternators of the maximum size for that speed have similar turbines attached to them. For instance, as above, a 1,000 kilowatt attached to a 1,000 kilowatt alternator at 3,000 revolutions per minute will have similar properties and characteristics to that of a 4,000 kilowatt turbine attached to a 4,000 kilowatt alternator at 1,500 revolutions per minute, and thus there is no limit to the size of turbo-alternator. In the case, however, of continuous current dynamos, the output of a dynamo (as it is chiefly limited by computation conditions which depend principally on the ampere turns on the armature per inch diameter) is practically only proportional to the speed, and it is easily seen that a limit is soon reached where the speed of the turbine is too low for economical conditions.

This statement that the output of a dynamo varies inversely as the speed is not exactly true, the real ratio in practice being as the 1¼ power of the speed, but still soon a limit is reached for continuous current work, and although we can make a 1,000 kilowatt alternator running at 3,000 revolutions per minute we can only make a 500 kilowatt continuous current dynamo to run at the same speed, or a 1,200 kilowatt to run at 1,500 revolutions per minute. The 500 kilowatts at 3,000 revolutions per minute is a very good machine, and so is the latter, but this is about the lowest speed at which a turbine can economically run at that size, and thus no one has put more than about 1,200 or 1,500 kilowatts into one dynamo. However, by using tandem dynamos it will be seen that the output is doubled, and this enables tandem turbo-dynamos up to about 4,000 kilowatts to be economically built.

In the design of marine turbines the same lines are followed exactly as in the design of land turbines, but in marine turbines the limitations of the screw propeller are to be dealt with instead of the limitations of dynamos, alternators, etc., in land work, and the importance of carefully balancing the efficiency of the propeller against the efficiency of the turbine has to be most fully considered. Screw propellers, as a rule, are more efficient the slower they go, turbines are less efficient the slower they go, and therefore the balance between the two has to be most carefully looked into. As a result it has been found that with simple installations of screw propellers and turbines it is not advisable to go in speed below 15 to 18 knots. This will be easily understood if we take, for example, the express Cunarders "Lusitania" and "Mauretania," and compare them with the "Carmania." The engines of both run about the same speed, viz., about 180 revolutions per minute, and yet for 25 knots in the "Mauretania there is a power of about 64,000 horse-power, and for 18 knots in the Carmania there is only about 20,000 horse-power. It is thus seen that, on account of the limitations of the screw propellers, while the turbines on the "Lusitania" and "Mauretania" are working under the best conditions possible, the turbines of the "Carmania" are not working under nearly so good conditions, and it was only on account of her very careful designing that the "Carmania" has proved to be the success she is.

(To be continued.)

INFLUENCE OF THUNDER UPON RAINDROPS.

During a thunderstorm which occurred on August 3d, 1908, at Alahärmä, Finland, W. J. Laine, who was studying these phenomena in behalf of the central meteorological bureau of the Finnish Society of Sciences, had the opportunity of observing a very curious phenomenon.

The storm, coming from the east, was traveling towards the observer's locality; the wind blew first from the N.E.[4], then during the storm from N.E.[5], and later from E.[1]. At the beginning the Western sky was perfectly clear. Thunder lasted from 5:50 to 6:24 P. M. (Helsingfors time), and rain from 6:23 to 7:25 P. M. Precipitation amounted to 2.2 millimeters.

To his great surprise, the observer noted that the rainbow, which was visible in the east between 6:15 and 6:30, with a clearly defined secondary rainbow, underwent, while it thundered, such vibrations that the limits of the colors, and particularly the edges of the main rainbow, and still more, those of the secondary rainbow, became quite uncertain, and at the same time the several colors lost their brilliancy and the entire rainbow vibrated rapidly. Since the interval between the observation of lightning and that of thunder was at first 20 seconds, and later about 5 seconds, it could be ascertained beyond doubt that the phenomenon was due to thunder and not to lightning.

The principal rainbow was very wide at first, red being absent almost entirely, and purple being prominent by an extraordinary intensity. Under this purple there was a clearly marked dark interval, especially in the secondary rainbow, and farther below, a narrow secondary band of a greenish purple. A little while later the colors disturbed by the shock became more distinct than before; yellow and red especially became more vivid. Both rainbows became narrower and the shocks affected only the secondary rainbow with a much diminished intensity. After each shock, the yellow portion seemed to increase in width and intensity. To the original colors of the two rainbows, a magnificent red was added, after a while, at the expense of the yellow portion, which was narrowed.

This interesting phenomenon may be utilized to clear up, to a certain extent, the old problem of ascertaining if acoustic vibrations within the atmosphere affect raindrops suspended in the air.

According to the rainbow theory brought out by J. M. Perntner (Meteorologische Optik, third section), the colors of the rainbow are attributed to the mixture of intensity maxima and minima of different wave lengths, which maxima and minima are produced by a remarkable diffraction phenomenon.

According to this theory, any variation in the size of the drops will alter the distance between maxima and minima and therefore the width, the limits and the shades of the several colors. A rapid and irregular succession of such phenomena could evidently produce the illusion of a vibrating rainbow.

The author's observations on the appearance of the rainbow show that the diameter of the raindrops, at first slightly under 1-10 of a millimeter, finally grew to ½ or even 1 millimeter. On the other hand, it has been established by Perntner's investigations that the distances between maxima and minima fluctuate most violently when the diameter of the drops is from 4-10 to ½ millimeter, and less and less as the diameter of the drops increases, being therefore much more prominent in the secondary rainbow than in the principal rainbow. In this manner we explain the gradual diminution of the vibrations with the increase in the diameter of the drops.

From the above remarks it follows that very violent acoustic shocks arising within the atmosphere, as in the case of thunder, can modify the size of raindrops by increasing their diameter.—Physikalische Zeitschrift.

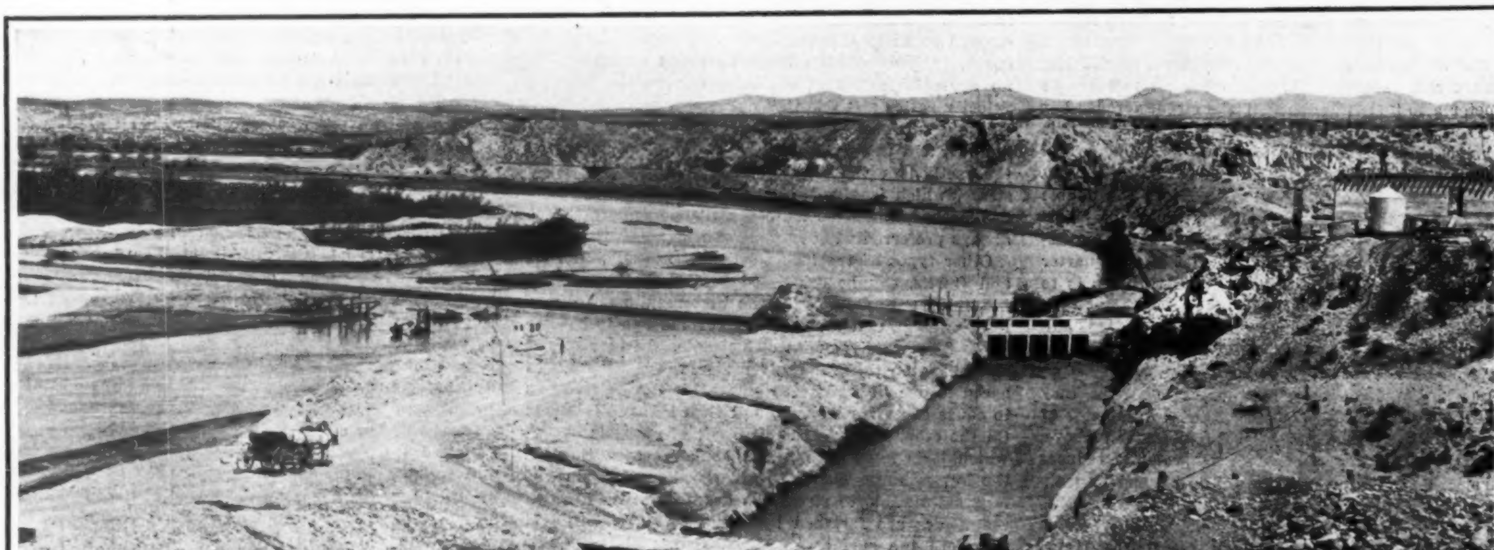
THE RIO GRANDE IRRIGATION PROJECT.

THE LARGEST RESERVOIR IN THE WORLD.

Concluded from Front Page.

though it is expected that the amount conserved by the project will be fully sufficient to irrigate 200,000 acres. Of this area, 110,000 acres lie in New Mexico, 45,000 in Texas, and 25,000 in Mexico proper. By a treaty between the United States and Mexico in settlement of claims on account of prior rights to the waters of the Rio Grande, this country agrees to deliver at the border, for the irrigation of the 25,000 acres lying in Mexico, 60,000 acre-feet annually. The remainder of the land pays the government for the project in ten annual installments after the completion of the undertaking. By the terms of the Reclamation Act no person may have water for more than 160 acres, but he must pay the annual installments for all the land he may own. This means that a person who may own more than the acreage allowed must sell and give some other one a chance. Uncle Sam considers that 160 acres of such valuable land is enough to guarantee any one an independent fortune if properly managed.

This section of the country is one of the garden spots of the world, the principal products being fruits of all kinds, truck, melons, onions, sweet potatoes, asparagus and alfalfa. Farm crops may be raised, but not so profitably as fruits and truck. Apples and pears yield on an average of 14,000 pounds and peaches 20,000 pounds to the acre. The receipts from these fruits will run from $300 to $600 an acre. Grapes will yield from $400 to $500 an acre, and berries even more, as high as $800 per acre being figured on strawberries. An acre put in cantaloupes will also bring about $800. Onions have yielded as high as 12,000 pounds to the acre, which means just about $1,500. Of course, fruit and truck are costly crops to raise, and the figures given are gross and not net; but even at that they are marvelous. Fruit growing is assuming large proportions in this section of the country, and as rapidly as new districts are brought under irrigation, new orchards are set out. In this locality there are now more than a million trees bearing fruits valued at approximately $220,000 annually, owing to the greater extent to the good work the Reclamation Service is doing and the helping hand so gladly extended by Uncle Sam toward making the desert awake from its long sleep, and blossom and bear fruit.



LEASBURG DAM AND HEADGATES OF RIO GRANDE CANAL LOOKING UPSTREAM.
RIO GRANDE IRRIGATION PROJECT.

AIR NITRATE FERTILIZERS.

Consul-General Frank H. Mason, of Paris, writing of the production of nitrogen from the atmosphere, and its use for economic purposes, especially as a fertilizer in agriculture, says that as thus far developed in Europe it is a direct sequel to the manufacture of calcium carbid by the application of electric heat to lime and carbon. He continues: When this process was discovered some years ago it was assumed that acetylene gas, generated from calcium carbid, would largely supplant coal gas and revolutionize the existing system of artificial lighting. The first essential requisite for carbid production was abundant and cheap electric current, and extensive plants were erected along water courses of Europe and preparations made to supply a large and steadily increasing demand.

But it was soon found that acetylene gas was a difficult, and, under certain conditions, a dangerous element to manage; its use became restricted to certain locations and conditions, and experience proved that the combined carbid factories had a capacity of about 100,000 tons in excess of the normal demand for that material.

About this time Frank and Caro, two German chemists, invented a process through which, by combining nitrogen gas with calcium carbid at a temperature of 1,000 degrees C (1832 F.) they could produce a combination of lime, carbon, and nitrogen—in other words, a synthetic nitrate of lime—to which they gave the name of cyanamid of calcium, now commonly known as cyanamid, which contains from 15 to 20 per cent of nitrogen, 60 per cent of lime, and has qualities as a fertilizer similar to sodium nitrate, or Chilean saltpeter. This process was patented in all countries and became the property of a corporate company, with headquarters at Rome and known as "La Société Italiana per la Fabrication de Prodetti Azotati."

The calcium carbid therefore was ready, the process for converting it into cyanamid by combination with nitrogen was perfected, and it only remained to provide an adequate supply of atmospheric nitrogen at a moderate cost. This requirement was met by a process invented by Dr. Carl von Linde, of Munich, which was patented in both France and the United States. By this process atmospheric air, having been first liquefied by compression, is subjected, by subsequent expansion under pressure, to a process of fractional distillation, by which the nitrogen is separated, leaving as a by-product oxygen of 50 to 60 per cent purity, which can be used by burning in the electric arc (sparking) for the manufacture of nitrates and nitric acid. (A copy of the French patent for the Linde process is on file in the Bureau of Manufactures.)

The cycle was now complete, and it is through the combination of these two processes—the Linde method for recovering atmospheric nitrogen and the Frank-Caro method of combining nitrogen with calcium carbid for the production of cyanamid of calcium—that European progress hopes to provide for the future an adequate supply of nitrate fertilizer for agricultural purposes.

Under licenses granted by the central company at Rome there are now established and in operation four or five plants for the production of cyanamid in Germany, one in Italy, one at Budapest, one or more in Norway, one in the United States—the American Cyanamid Company, with offices at New York, and works at Niagara Falls—and one in France, the Société des Produits Azotes, with offices at Paris and large plants at Notre Dame de Briancon, in the Department of Savoie, France, and at Martigny, Switzerland. The establishment at Notre Dame de Briancon is the only one of its kind in France. It is elaborately described, with illustrations of buildings and machinery, and with complete scientific analysis of the entire process, in the Genie Civil, for August, 1909

(a copy of which is on file in the Bureau of Manufactures).

This company has a capacity at Briancon of 120 cubic meters (4,238 cubic feet) of nitrogen gas per hour, and in 1909 produced about 900 tons of cyanamid. This year it has turned out during the first three months 1,000 tons, and expects to produce during the year at its two plants in France and Switzerland from 9,000 to 10,000 tons. Even at this increased rate of production it is unable to supply the rapidly growing demand, as the use of nitrate fertilizers is steadily expanding in France.

The German companies produced during the year ended May 30th, 1909, 3,500 tons of cyanamid, and since that date 3,500 tons. Their capacity is being steadily increased. The largest plant thus far in Europe is that of the Northwestern Cyanamid Company at Adda, Norway, which produces 500 cubic meters (17,657 cubic feet) of nitrogen gas per hour, and it is reported that the capacity of that establishment is to be doubled. All accounts agree that the demand for cyanamid everywhere exceeds the available supply, and most of the manufacturing companies are planning greatly to increase their productive capacity.

The Society at Paris sells cyanamid in two grades or qualities, according to the percentage of nitrogen contained, as follows: Quality 1, containing 15 per cent of nitrogen, 21 to 22 francs per 100 kilogrammes (220½ pounds) ($40.50 to $42.40 per metric ton of 2,204 pounds); quality 2, containing 18 to 20 per cent nitrogen, 1.42 francs (27.4 cents) per kilogramme (2.204 pounds) of nitrogen contained.

As Chilean nitrate is quoted at 1.55 francs (30 cents) per kilogramme of nitrogen, it will be apparent that cyanamid is already in a position to compete successfully with the natural nitrate in respect to price. It remains to establish their comparative values for the purpose of agriculture.

ITS EFFICIENCY IN AGRICULTURE—OTHER USES.

Elaborate experiments have been made with cyanamid in competition with sodium nitrate, sulphate of ammonia, and other chemical fertilizers for stimulating the growth of cereals, sugar beets, potatoes, and other crops. These tests have been made at various places in France, England and Germany. The reports of these experiments are voluminous and in some minor details conflicting, but they are practically unanimous in according to cyanamid the essential qualities of a high-class fertilizer.

It can be readily produced with a nitrogen content of 18 to 20 per cent combined with about 60 per cent of lime. It is more stable than Chilean nitrate, dissolves slowly in contact with wet soil, and yields its nitrogen gradually as it is required by the growing plants. Some of its most beneficial effects have been noted in soils deficient in lime, and where it was applied at the time of or a few days previous to the planting of the seed.

The Agricultural Syndicate of the Department of Vaucluse has petitioned the Central Union of Agricultural Syndicates in Paris in favor of erecting on the river Durance, near Sisteron, a plant for the manufacture of artificial nitrates on their own account. This is the first move of the farmers of France to secure an increased supply of the new fertilizer at cost of production and independent of the market as controlled by manufacturing companies.

Cyanamid is sold in the form of a coarse, dark-colored powder, which is distributed on the land by a two-wheeled planter or drilling machine drawn by one horse. The quantity varies with different crops and soils from 200 to 250 kilogrammes (440.9 to 551.2 pounds) per hectar (2.47 acres), or about 200 pounds per acre.

Nitrogen gas is also used for several minor purposes, among which are: (1) In the manufacture of metallic filaments for incandescent lamps, nitrogen is used in heating the filaments where air containing oxygen would oxidize and destroy certain elements in the metal; (2) for manipulating certain liquids which would deteriorate or become explosive by exposure to the air. Nitrogen gas compressed to a pressure of 300 pounds is sold in Paris at prices ranging from 38 to 48 cents per cubic meter (35.31 cubic feet.)

LEASBURG DIVERSION DAM AND INTAKE GATES OF MAIN RIO GRANDE CANAL.

NEW MONORAIL CARS.

Consul Thomas H. Norton, of Chemnitz, furnishes the following information concerning a new monorail car, perfected and patented by a Belgian engineer:

An essential feature of this new system, the isopedin, is the use of two forms of wheels as mobile supports of a car. Two or more strong, heavy wheels in a tandem sequence directly under the axis of the car, are constructed with the proper flanges so as to run upon a monorail, and two additional wheels larger but lighter, one on each side of the car at the extremity of an axle. The first series support the load almost entirely, and are directly coupled with the motive power, as well as subject to the action of the brakes; the second pair of wheels serve simply to maintain equilibrium, carrying but a fraction of the load, the effects of any unevenness of the ground over which they move being communicated in very slight degree to the framework of the car.

The advantage in this new system is in the cheapness of construction, dispensing with the gyroscope attachment and with its motor, air pump, air-tight inclosure, etc. There is also a saving in weight.

The essential principle of the new system has been promptly recognized as available for automobile construction. The first trials of such an automobile took place at Berlin in March and were thoroughly satisfactory. The trial vehicle has two seats and is supported on two strong wheels, one before the other. By a simple mechanism two light wheels, one on either side, can be lowered at will so as to run even on the ground with the main pair of wheels, while being in firm but elastic connection with the body of the car. The supplementary pair of wheels is of manifest assistance at starting and stopping, as well as when passing over slippery places. While in motion the car is not unlike a motor cycle. Its advantages over the latter are the comfortable seat, the accommodation of more than one person, the arrangements for baggage, and the ease in starting or stopping. In comparison with the prevalent types of automobiles, and more particularly runabouts, there is a vast economy in cost of construction, in cost of running, and in wear and tear, while the vehicle can pass through narrow places and over paths totally inaccessible to the four-wheeled vehicle.

In a paper which he read before the Manchester Association of Engineers, Mr. G. B. Storie, of Rockdale, states that although the application of the steam turbine to the driving of textile mills dates no further back than nine or ten years, there are to-day not less than 480 turbines in use for that purpose, aggregating 300,000 horse-power. About 3 per cent of that number are for mechanical driving, the remainder being coupled direct to electric generators supplying current to motors in electrically driven mills, nearly all of which are for alternating-current work. The commutator troubles experienced with the earlier direct-current generators may account to some extent for the general adoption of alternating current; it is more likely, however, to be due to the advantages offered by the induction type of motor for the driving of spinning and weaving machinery. The bulk of these turbines are working in America and on the Continent, where electric driving has made more rapid progress than in this country. Probably the largest turbine yet installed for textile mill work is that at Pacific Mills, Lawrence, Mass. It has an output of 3,250 kilowatts.

A HOME AT LAS CRUCES, NEW MEXICO. MESILLA VALLEY IN IRRIGATED DESERT.

RIO GRANDE IRRIGATION PROJECT.

RECENT PROGRESS IN AVIATION.—IV.*

CHRONOLOGY OF AVIATION.†

Compiled by O. Chanute.

Concluded from Supplement No. 1805, Page 90.

Bewildering advance in aviation took place in 1908 and 1909. When it is remembered that the first successful man flight, landing safely, was made by Wright brothers December 17th, 1903, that it took them two years—1904-1905—to obtain entire control over their machine; that the Santos-Dumont flight of 720 feet, November 13th, 1906, excited the wonder and admiration of all Europe, we can realize partially the progress made, now that flights of over 100 miles have been made, that a height of 1,600 feet is said to have been attained, that there are hundreds of successful experimenters in the field and that records are being broken every few days.

It would be quite futile to give a compendium of all the flights made in 1909. They number thousands. The profitable thing which can be done is to tabulate the more remarkable performances; and, in order to mark the advance, to include therewith the former feats of the same aviator, which excited wonder only one or two years ago. The most interesting of these are prefixed with a star.

During 1909 exhibitions of aviating apparatus were held in Paris, December 24-30th, 1908; in London, March 19-27th; in London again July 6th to August 4th, in Frankfort July 10th to October 10th, in Paris again September 25th to October 17th, and these drew great crowds; while meets, contests and tournaments were held at Rheims August 22nd to 29th, at Brescia September 5th to 20th, at Berlin September 26th to October 3rd, at New York September 25th to October 2nd, at St. Louis October 4th to 10th, at Paris October 2nd to 21st, and at Blackpool and at Doncaster, October 15th to 23rd.

The events which have attracted most attention have been the cross-country flight of H. Farman, from Bouy to Rheims, 17 miles, without landing, October 30th, 1908; of Blériot, October 31st, 1908, from Toury to Artenay and return with landings; of the same man from Etampes to Chevilly, 26 miles, July 13th, 1909, and his flight across the British Channel, July 25th; the two unsuccessful attempts of Latham to perform the same feat, July 19th and July 27th, 1909; the flight of Farman July 23rd, from Chalons to Suippes, 40 miles; of his flights at Rheims of 112 miles August 27th, and of 150 miles at Mourmelon, November 3rd; of Orville Wright at Fort Myer, July 27th and 30th; of W. Wright at New York, October 4th; of Curtiss at Rheims August 28-29th; of Latham over Berlin September 27th and of De Lambert over Paris October 18th, as well as a speed of about 90 miles an hour down wind at Blackpool, attained by Latham October 22nd, 1909.

These feats have not been accomplished without some deplorable accidents. Several aviators have been killed or injured by the fall of their machines and many of the latter have been smashed. It will be remembered that Lieut. Selfridge was killed at Fort Myer, September 17th, 1908. In 1909, Eugene Lefebvre was killed at Juvissy September 7th; on the same day Enea Rossi was killed at Rome while testing a machine of his own invention; while on September 22nd the distinguished propagandist of aviation in France, Capt. L. F. Ferber, was killed at Boulogne by an unlucky landing. On December 6th, A. Fernandez, a French aviator of Spanish birth, was killed at Nice by the fall of his biplane, similar to Wright's, caused by the explosion of his motor when at a height estimated at 500 meters.

The tendency has been to develop special experts for exhibition flights. Some 200 of their flights, which are thought the more memorable for one reason or another, will be found in the accompanying list.

CHINESE RED TUBEROSES.

In regard to the allegation, published in the United States some time since, that the Chinese florists of Tientsin grow tuberoses of a red color, and perhaps of other shades, Consul-General Samuel S. Knabenshue makes the following report:

Some time since, this consulate received a letter from a florist in the United States, inclosing a sum of money, with the request that he be furnished with its value in red tuberose bulbs. He stated that he had been informed by a gentleman who had traveled in China that he had seen red tuberoses grown by native florists in Tientsin.

Inquiry was made of a German florist here, a resident for many years, who stated that there is no natural red tuberose, but that the flowers are artificially colored. As the tuberose of the ordinary white variety is near flowering, the flower stalks are cut off close to the ground and are placed in water in which is dissolved a red earth, of whose composition he is ignorant. The coloring matter is drawn up into the flowers, tinting them red—the first that appear being very slightly tinged, but the color becoming more pronounced in those which open later. He also stated that the red color can be produced in this way by using aniline colors, not only red, but any other aniline color which may be desired. Native gardeners, however, insisted that natural red tuberoses were grown, but declined to sell bulbs of the alleged red

* Paper read before the Western Society of Engineers, and here reprinted from its journal.

† The accompanying table, compiled by the author, is through the courtesy of the World Almanac, 1910.

CHRONOLOGY OF MEMORABLE FLIGHTS—MOTOR AEROPLANES.

WILBUR WRIGHT.

Date.	Machine.	Place.	Distance.	Time. H. M. S.	Persons.	Remarks.
*Dec. 17, 1903...	Biplane........	Kitty Hawk...	852 ft.	0 00 59	1	First successful man flight in history.
Nov. 9, 1904...	Biplane........	Dayton, O.....	3 miles	0 4 40	1	Made 105 flights that year.
Oct. 5, 1905...	Biplane........	Dayton, O.....	24 miles	0 38 00	1	Made 49 flights that year.
Aug. 8, 1908...	Biplane........	Mans	....	....	1	Short flights showing control.
*Sept. 21, 1908...	Biplane........	Auvours	41 miles	1 31 00	1	Made over 100 flights here.
Oct. 10, 1908...	Biplane........	Auvours	46 miles	1 9 00	2	With Mr. Painleve; took 35 others.
*Dec. 18, 1908...	Biplane........	Auvours	62 miles	1 54 00	1	Rose to 360 ft.; then world record.
*Dec. 31, 1908...	Biplane........	Auvours	77 miles	2 20 23	1	Won Michelin prize; world record.
Mar. 20, 1909...	Biplane........	Pau, France...	....	6 00	1	No previous propulsion; teaches 3 pupils.
Apr. 16, 1909...	Biplane........	Rome	....	....	2	Took up many passengers.
Apr. 24, 1909...	Biplane........	Rome	....	....	1	No previous propulsion.
*Sept. 29, 1909...	Biplane........	New York.....	....	....	1	Sircled Statue of Liberty.
*Oct. 4, 1909...	Biplane........	New York.....	21 miles	0 33 33	1	To Grant's tomb and return.

ORVILLE WRIGHT.

Date.	Machine.	Place.	Distance.	Time. H. M. S.	Persons.	Remarks.
Sept. 9, 1908...	Biplane........	Fort Myer....	40 miles	0 62 00	1	Unofficial; rose to 100 feet.
*Sept. 12, 1908...	Biplane........	Fort Myer....	50 miles	1 15 00	1	Longest flight of 1908.
*Sept. 17, 1908...	Biplane........	Fort Myer....	3 miles	0 4 00	2	Selfridge killed; Wright injured.
July 20, 1909...	Biplane........	Fort Myer....	....	1 20 00	1	Unofficial test.
July 21, 1909...	Biplane........	Fort Myer....	....	1 29 00	1	Unofficial test.
*July 27, 1909...	Biplane........	Fort Myer....	....	1 13 00	2	Official time test; machine accepted.
*July 30, 1909...	Biplane........	Fort Myer....	10 miles	0 14 00	2	Official speed test; 42 miles per hour
Aug. 29, 1909...	Biplane........	Berlin	....	0 15 00	1	Many preliminary exhibitions.
Sept. 4, 1909...	Biplane........	Berlin	....	0 53 00	1	
Sept. 8, 1909...	Biplane........	Berlin	....	0 17 00	2	With Capt. Hildebrandt.
Sept. 9, 1909...	Biplane........	Berlin	....	0 15 00	2	With Capt. Englehardt.
Sept. 17, 1909...	Biplane........	Berlin	....	0 54 26	1	In presence of Empress rose to 563 ft.
*Sept. 18, 1909...	Biplane........	Berlin	....	1 35 47	2	With Capt. Englehardt.
Oct. 2, 1909...	Biplane........	Berlin	....	0 10 00	2	With Crown Prince of Germany.
*Oct. 4, 1909...	Biplane........	Berlin	21 miles	0 33 33	1	Reached h'ght of 1,600 ft.; unofficial world rec'd

A. SANTOS DUMONT.

Date.	Machine.	Place.	Distance.	Time. H. M. S.	Persons.	Remarks.
*Nov. 13, 1906...	Cellular........	Bagatelle	720 ft.	0 21 00	1	First flight in Europe.
Nov. 17, 1907...	Biplane........	Issy	500 ft.	....	1	Made several flights.
Nov. 21, 1907...	Monoplane	Bagatelle	400 ft.	....	1	Made several flights.
Mar. 10, 1909...	Monoplane	Bagatelle	1,300 ft.	....	1	With the Libellule.
Apr. 10, 1909...	Monoplane	St. Cyr.........	1.2 miles	....	1	With the Demoiselle.
June 19, 1909...	Monoplane	Issy	820 ft.	....	1	Several other flights.
*Sept. 13, 1909...	Monoplane	St. Cyr.........	8 miles	0 12 00	1	St. Cyr to Buc to visit friend.
*Sept. 17, 1909...	Monoplane	St. Cyr.........	10 miles	0 16 00	1	Across country.

LEON DELAGRANGE.

Date.	Machine.	Place.	Distance.	Time. H. M. S.	Persons.	Remarks.
Mar. 16, 1907...	Biplane	Bagatelle	30 ft.	....	1	First Voisin aeroplane.
*Mar. 20, 1908...	Biplane	Ghent	453 ft.	....	2	First flight with passenger (Farman).
Apr. 11, 1908...	Biplane	Issy	2.43 miles	0 6 30	1	Won Archdeacon cup.
May 27, 1908...	Biplane	Rome	7.90 miles	0 15 26	1	In presence of King, etc.
June 22, 1908...	Biplane	Milan	10.50 miles	0 16 30	1	Best flight on Italian trip.
*July 8, 1908...	Biplane	Turin	500 ft.	....	2	First woman passenger (Mrs. Peltier)
Sept. 6, 1908...	Biplane	Issy	15.2 miles	0 29 53	1	Beat then existing records.
May 23, 1909...	Biplane	Juvissy	3.6 miles	0 10 18	1	Won Lagatineri prize.
June 12, 1909...	Biplane	Juvissy	3.7 miles	....	1	Circling across country.
Aug. 23, 1909...	Monoplane	Reims	....	0 11 4	1	Won tenth prize; speed.
Aug. 27, 1909...	Monoplane	Reims	31 miles	....	1	Won eighth prize; distance.
Sept. 18, 1909...	Monoplane	Denmark	....	0 15 00	1	Before King, at Aarhus.
Oct. 16, 1909...	Monoplane	Doncaster	5.75 miles	0 11 25	1	To keep crowd from grumbling.
*Oct. 26, 1909...	Monoplane	Doncaster	6 miles	0 7 36	1	Over 50 miles an hour.

HENRY FARMAN.

Date.	Machine.	Place.	Distance.	Time. H. M. S.	Persons.	Remarks.
Oct. 26, 1907...	Biplane	Issy	253 ft.	....	1	First sweeps a half circle.
May 30, 1908...	Biplane	Ghent	0.77 miles	....	2	With Mr. Archdeacon.
July 6, 1908...	Biplane	Ghent	12.2 miles	0 19 3	1	Won Armengaud prize.
*Oct. 30, 1908...	Biplane	Chalons	17 miles	0 20 00	1	Cross country, Chalons to Reims.
Oct. 31, 1908...	Biplane	Chalons	....	0 23 00	1	Eighty-two feet altitude; won prizes.
July 18, 1909...	Biplane	Chalons	....	1 23 00	1	His first long flight.
*July 23, 1909...	Biplane	Chalons	40 miles	1 5 00	1	Cross country, Chalons to Suippe.
*Aug. 27, 1909...	Biplane	Reims	112 miles	3 4 57	1	First prize for distance and time up.
Aug. 27, 1909...	Biplane	Reims	6 miles	0 10 00	3	With two passengers; won prize.
*Oct. 3, 1909...	Biplane	Berlin	62 miles	1 40 00	1	Won third prize, $960.
Oct. 18, 1909...	Biplane	Blackpool	14 miles	0 23 00	1	On first day of meeting.
*Oct. 20, 1909...	Biplane	Blackpool	47 miles	1 32 16	1	Won prize of $10,000.
*Nov. 3, 1909...	Biplane	Mourmelon ...	137.25 miles	4 6 25	1	Said to be 150 miles; 4h. 17m. 35s.

LOUIS BLERIOT.

Date.	Machine.	Place.	Distance.	Time. H. M. S.	Persons.	Remarks.
Aug. 6, 1907...	Langley	Issy	470 ft.	....	1	His first attempt to circle.
July 4, 1908...	Monoplane	Issy	3.7 miles	0 5 47	1	Swept several circles.
Oct. 21, 1908...	Monoplane	Toury	4.25 miles	0 6 40	1	At height of 65 feet.
Oct. 31, 1908...	Monoplane	Toury	8.7 miles	0 11 00	1	Toury to Artenay, landed.
Oct. 31, 1908...	Monoplane	Toury	8.7 miles	....	1	Artenay to Toury; intermediate landing.
May 30, 1909...	Monoplane	Issy	8.7 miles	....	1	Over the adjoining fields.
*June 12, 1909...	Monoplane	Juvissy	984 ft.	....	3	Santos Dumont and Fournier as passengers.
*July 13, 1909...	Monoplane	Mondesir	26 miles	0 44 30	1	Etampes to Chevilly, cross country.
*July 25, 1909...	Monoplane	Calais	32 miles	0 37 00	1	First flight across British Channel.
*Aug. 28, 1909...	Monoplane	Reims	6.3 miles	0 7 48	1	Won first prize speed for 6-mile trip.
Aug. 27, 1909...	Monoplane	Reims	25 miles	0 41 00	1	Won ninth prize for distance flown.

S. F. CODY.

Date.	Machine.	Place.	Distance.	Time. H. M. S.	Persons.	Remarks.
Feb. 22, 1909...	Biplane	Aldershot	1,200 ft.	....	1	In a 12-mile wind.
May 14, 1909...	Biplane	Aldershot	1 mile	....	1	On the army biplane.
July 21, 1909...	Biplane	Aldershot	4 miles	....	1	On rebuilt machine.
Aug. 29, 1909...	Biplane	Aldershot	10 miles	....	2	With passenger in three flights.
*Sept. 8, 1909...	Biplane	Aldershot	40 miles	1 3 00	1	Circuit to Farnborough and return.
Sept. 11, 1909...	Biplane	Aldershot	....	....	1	Before Empress Eugenie.
Oct. 16, 1909...	Biplane	Doncaster	3,000 ft.	....	1	Machine wrecked; aviator hurt.

MOORE-BRABAZON.

Date.	Machine.	Place.	Distance.	Time. H. M. S.	Persons.	Remarks.
Jan. 28, 1909...	Biplane	Chalons	3.1 miles	....	1	Learning use of Voisin machine.
Feb. 24, 1909...	Biplane	Issy	1.2 miles	....	1	Swept over two circles.
Feb. 28, 1909...	Biplane	Issy	2.5 miles	....	1	Several flights.
April 30, 1909...	Biplane	England	4.5 miles	....	1	Gradually improves performances.
Oct. 30, 1909...	Biplane	Shell Beach...	....	....	1	Won Daily Mail $5,000 prize for flight with a British machine.

L. F. FERBER.

Date.	Machine.	Place	Distance.	Time. H. M. S.	Persons.	Remarks.
Aug. 8, 1908...	Biplane	Issy	....	....	1	First trials with motor machine.
Sept. 19, 1908...	Biplane	Issy	1,640 ft.	....	1	His aeroplane No. 9.
June 13, 1909...	Biplane	Juvissy	3.1 miles	0 5 30	1	On a Voisin machine.
*Sept. 15, 1909...	Biplane	Boulogne	6 miles	0 9 00	1	Boulogne to Wimeroux.
Sept. 22, 1909...	Biplane	Boulogne	1 mile	....	1	Landed in ditch; killed.

ESNAULT PELTERIE.

Date.	Machine.	Place.	Distance.	Time. H. M. S.	Persons.	Remarks.
Oct. 19, 1907...	Monoplane ...	Buc	....	....	.....	First short flights.
June 8, 1908...	Monoplane ...	Buc	0.75 miles	....	1	At height of 100 ft.

HUBERT LATHAM.

DATE.	Machine.	Place.	Distance.	Time. H. M. S.	Persons.	Remarks.
May 19, 1909	Monoplane	Chalons	1,640 ft.		1	Begins operating the Antoinette.
June 5, 1909	Monoplane	Chalons		1 7 37	1	In wind and rain; breaks record.
June 6, 1909	Monoplane	Juvissy	10 miles		1	Cross country flight.
June 12, 1909	Monoplane	Juvissy	30 miles	0 39 00	1	Won Goupy prize.
*July 19, 1909	Monoplane	Calais	11 miles		1	Over British Channel; fell in sea.
*July 27, 1909	Monoplane	Calais	20 miles		1	British Channel; fell near Dover.
*Aug. 26, 1909	Monoplane	Reims	96 miles	2 18 9	1	Won second prize for distance.
*Aug. 27, 1909	Monoplane	Reims			1	Won first prize altitude, 508 ft.
*Sept 27, 1909	Monoplane	Berlin	6.5 miles	0 13 00	1	Across suburbs of Berlin.
Sept. 29, 1909	Monoplane	Berlin	42 miles	1 10 00	1	Won second prize for distance.
Sept. 30, 1909	Monoplane	Berlin	51 miles	1 23 00	1	Machine broken in landing.
*Oct. 22, 1909	Monoplane	Blackpool			1	Flew in gale; won prize, $1,500.
Nov. 19, 1909	Monoplane	Chalons		10	1	Rose 1,345 ft., competing, Weiler prize.
Dec. 1, 1909	Monoplane	Mourmelon			1	Rose 1,500 ft. in 40-mile wind.

LOUIS PAULHAN.

DATE.	Machine.	Place.	Distance.	Time. H. M. S.	Persons.	Remarks.
*July 10, 1909	Biplane	Douai	1.25 miles		1	His very first flight.
July 15, 1909	Biplane	Douai		1 17 00	1	Reached altitude of 357 ft.
*July 19, 1909	Biplane	Douai	12.1 miles	0 22 53	1	Cross country, Douai to Arras.
July 23, 1909	Biplane	Douai	43.5 miles	1 17 19	1	Official allowance, 30 miles.
Aug. 6, 1909	Biplane	Dunkerque		0 18 20	1	Altitude, 200 ft.
Aug. 7, 1909	Biplane	Dunkerque	33 miles	0 33 00	1	On a Voisin biplane.
Aug. 24, 1909	Biplane	Reims	18.6 miles	0 38 12	1	Altitude, 295 ft.
*Aug. 25, 1909	Biplane	Reims	81 miles	2 43 24	1	Won third prize for distance.
Sept. 9, 1909	Biplane	Tournai	12.4 miles	0 17 00	1	Two cross country flights.
*Sept. 13, 1909	Biplane	Tournai		1 35 00	1	Tournai to Taintignies and return.
Sept. 17, 1909	Biplane	Ostend	1.24 miles	0 3 16	1	Circled over sea.
Sept. 18, 1909	Biplane	Ostend		1 1 1	1	Over sea front; won $5,000 prize.
Oct. 10, 1909	Biplane	P. Aviation	21.5 miles	0 21 48	1	Flew over line of the stands.
Oct. 12, 1909	Biplane	P. Aviation	3.6 miles	0 6 11	1	Won prize for slowest flight, $600.
Oct. 18, 1909	Biplane	Blackpool	14 miles	0 25 53	1	On first day of Blackpool meeting.
*Oct. 19, 1909	Biplane	Blackpool	15.75 miles	0 32 18	1	Won third prize for distance, $1,400.
Nov. 19, 1909	Biplane	Chalons			1	Rose 1,210 ft., competing, Weiler prize.
*Nov. 20, 1909	Biplane	Mourmelon	37 miles	0 55 00	1	Chalons and return. Rose nearly 1,000 ft.

ROGER SOMMER.

DATE.	Machine.	Place.	Distance.	Time. H. M. S.	Persons.	Remarks.
July 4, 1909	Biplane	Chalons	3.75 miles		1	On Farman's new machine.
July 18, 1909	Biplane	Chalons		1 4 00	1	Longest of several flights.
*July 27, 1909	Biplane	Chalons	25 miles	1 23 30	1	To Vadenay and back.
Aug. 1, 1909	Biplane	Chalons		1 50 30	1	Beats all French records.
*Aug. 2, 1909	Biplane	Chalons	9 miles	0 12 00	1	To Suippes; 45 miles an hour.
Aug. 4, 1909	Biplane	Chalons		2 0 10	1	Trying to beat Wright's record.
*Aug. 7, 1909	Biplane	Chalons		2 27 15	1	Beats Wright's record of December 31, 1908.
Aug. 22, 1909	Biplane	Reims		1 19 33	1	On first day of Reims tournament.
Aug. 27, 1909	Biplane	Reims	37 miles		1	Won seventh prize for distance.
Sept. 6, 1909	Biplane	Nancy	25 miles	0 35 00	1	Also made flights with passengers.
Sept. 10, 1909	Biplane	Nancy	18 miles		1	Accompanies troops on review.
Sept. 11, 1909	Biplane	Nancy	24 miles		1	Nancy to Lenoncourt.
Oct. 16, 1909	Biplane	Doncaster	9.7 miles	0 21 45	1	Best flight in Great Britain to date.
*Oct. 26, 1909	Biplane	Doncaster	29.7 miles	0 44 53	1	Won Whitworth cup.

M. ELLEHAMMER.

DATE.	Machine.	Place.	Distance.	Time. H. M. S.	Persons.	Remarks.
1906-1909	Biplane	Denmark			1	Experience with varied success.

ALEXANDER GRAHAM BELL.

DATE.	Machine.	Place.	Distance.	Time. H. M. S.	Persons.	Remarks.
1907-1909		Baddeck				Experiments; tetrahedral machine.

COUNT DE LAMBERT.

DATE.	Machine.	Place.	Distance.	Time. H. M. S.	Persons.	Remarks.
Mar. 17, 1909	Biplane	Pau		0 3 00	1	First flight alone; Wright's pupil.
Mar. 24, 1909	Biplane	Pau	15.6 miles	0 27 11	1	Wins Aero Club prize for 250 metres.
Mar. 27, 1909	Biplane	Pau		0 7 56	1	Flies beyond experimental field.
April 13, 1909	Biplane	Pau		0 1 30	2	With Delagrange as passenger.
*Aug. 26, 1909	Biplane	Reims	72 miles	1 52 00	1	Won fourth prize; distance.
*Oct. 18, 1909	Biplane	Juvissy	31 miles	0 49 39	1	To Eiffel Tower and back across Paris.
Oct 21, 1909	Biplane	Pt. Aviation	1.25 miles	0 1 57	1	Wins $3,000 prize for speed.

PAUL TISSANDIER.

DATE.	Machine.	Place.	Distance.	Time. H. M. S.	Persons.	Remarks.
May 20, 1909	Biplane	Pau	35.7 miles		1	Pupil of W. Wright.
Aug. 22, 1909	Biplane	Reims	18.6 miles	0 29 00	1	Won third prize for speed over 30 kilometres.
*Aug. 27, 1909	Biplane	Reims	69 miles	1 46 32	1	Won sixth prize for distance flown.

E. LEFEBVRE.

DATE.	Machine.	Place.	Distance.	Time. H. M. S.	Persons.	Remarks.
July 21, 1909	Biplane	La Haye	2 miles		1	Self taught on Wright machine.
*Aug. 27, 1909	Biplane	Reims	12.4 miles	0 20 47	1	Shows great boldness and skill.
Aug. 28, 1909	Biplane	Reims		0 11 5	2	Performs evolutions with passenger.
Sept. 7, 1909	Biplane	Juvissy	1,800 ft.		1	Upset and killed.

MARIO CALDERARA.

DATE.	Machine.	Place.	Distance.	Time. H. M. S.	Persons.	Remarks.
April 28, 1909	Biplane	Rome		0 10 00	1	Pupil of W. Wright.
May 6, 1909	Biplane	Rome			1	Upset and hurt.
Sept. 12, 1909	Biplane	Brescia	6.3 miles		2	One passenger; won prize.
*Sept. 15, 1909	Biplane	Brescia	5.6 miles		2	Won Oldofredl prize.
*Sept. 20, 1909	Biplane	Brescia	31 miles	0 50 51	1	Won second prize for speed.

GLEN N. CURTISS.

DATE.	Machine.	Place.	Distance.	Time. H. M. S.	Persons.	Remarks.
*July 4, 1908	Biplane	H'mondsp't	5,090 ft.	0 1 42	1	Wins Scientific American Cup.
July 13, 1909	Biplane	Mineola	1.5 mile	0 3 00	1	Tuning up Aeronautic Society machine.
July 17, 1909	Biplane	Mineola	15 miles	0 21 00	1	Described figure 8.
July 18, 1909	Biplane	Mineola	30 miles	0 52 30	1	Official distance, 25 miles.
*July 24, 1909	Biplane	Mineola	25 miles	0 52 30	1	Second winning Scien. American cup.
Aug. 24, 1909	Biplane	Reims	6.2 miles	0 8 35	1	Wins second prize; speed over 10 kilometres.
Aug. 25, 1909	Biplane	Reims	6.2 miles	0 8 11	1	Bleriot is 7 seconds faster.
Aug. 26, 1909	Biplane	Reims	19 miles	0 29 00	1	Wins tenth prize; distance and speed.
*Aug. 28, 1909	Biplane	Reims	12.4 miles	0 15 56	1	Wins Gordon Bennett cup.
*Aug. 29, 1909	Biplane	Reims	18.6 miles	0 23 30	1	Wins first prize, speed over 30 kilometres.
*Aug. 29, 1909	Biplane	Reims	6.2 miles	0 7 51	1	Wins second prize, speed over 10 kilo.
Sept. 11, 1909	Biplane	Brescia	31 miles	0 49 24	1	Wins first prize for speed.
Sept. 29, 1909	Biplane	New York			1	Flights about Governor's Island.
Oct. 10, 1909	Biplane	St. Louis			1	Flights at Centennial celebration.
Oct. 16, 1909	Biplane	Chicago	1 mile	0 1 30	1	Exhibition flights.

J. A. D. MCCURDY.

DATE.	Machine.	Place.	Distance.	Time. H. M. S.	Persons.	Remarks.
May 18, 1908	Biplane	H'mondsp't	600 ft.		1	With the White Wing.
July 4, 1908	Biplane	H'mondsp't	3,420 ft.		1	With the June Bug.
Feb. 23, 1909	Biplane	Baddeck	2,640 ft.		1	With the Silver Dart.
Feb. 24, 1909	Biplane	Baddeck	4.5 miles		1	With the Silver Dart.
Mar. 11, 1909	Biplane	Baddeck	19 miles	0 22 00	1	With the Silver Dart.
Mar. 18, 1909	Biplane	Baddeck	16 miles		1	Aggregate of 1,000 miles.
Aug. 2, 1909		Petawawa	20 miles		1	Many flights; broke machine.

variety with a guarantee that the bulbs would produce red flowers, the payment to be withheld until the bulbs were tested.

Finally a native gardener admitted that these are bulbs of the ordinary white tuberose, reared in ordinary flower-pots in this way: The opening in the bottom of the pot is closed with a cork; the pot is filled with earth mixed to a mud with water in which the coloring matter has been dissolved; the bulbs are planted in this after a number of small incisions have been made in the lower half of the bulb above the roots; a thin covering of uncolored earth is placed over the earth in the pot to conceal the colored portion below, and the plant is supplied with water in which the coloring matter has been dissolved. The resulting flowers have the tint of the coloring matter used.

ANTIQUITIES IN MAGNA GRÆCIA.

A NOTABLE monument of antiquity has just been brought to light in Magna Græcia. The discovery was made accidentally when the Italian Ministry of Marine determined upon an enlargement of the arsenal at Tarranto.

The ensuing excavations, which were begun in September, 1908, have resulted in the uncovering of no fewer than 414 tombs, together with a vast and valuable collection of funeral utensils, ornaments, etc.

Sepultures in the sixth and seventh centuries B. C. took place either in bare earth or stone sarcophagi, and within these tombs were always buried a number of small objects meant for the use and comfort of the departed loved one, the most commonly found being articles of jewelry, toilet implements, vases holding perfumes and unguents, together with amphoræ jugs, and cups for beverages or other personal necessities.

Among the vast quantity of such things discovered may be mentioned earrings of terra cotta, cups, jewels of wrought metal, collars or necklaces adorned with golden leaves, etc. Some of the tombs are conjugal sepulchres, it being a common practice for happily married couples to be buried together. Perhaps the most valuable of all the recovered treasures, from the antiquarian's point of view, are the potteries, which attest what a high degree of perfection the art of ceramics had reached in Magna Græcia at this early date.

In one tomb were found Corinthian amphorettes, ornamented with swans and wild animals; an alabastrum decorated with the Harpy-siren with spread wings—the symbol of the genius of funerals—and three rare cyrenaic Kylikes, two of which have interior decorations of huge fish.

All these vessels are now exhibited in a glass case at the Museum of Tarranto.

Particularly interesting is a Kylix cyrenaic which has in the interior a figure of Jove with his symbol, the eagle, and outside a huge decoration of lines and flowers.

Another rare example of this valuable sepulchral cup is found in the Louvre. Cyrenaic pottery is indeed as rare as precious stones in the eyes of the archæologist. The present example is of the date of 580 B. C.

A beautiful vase belonging to the fifth century shows a charming bacchic dance.

But most fortunate and most important of all the discoveries are the sculptures. Many fragments of clay statues, skilled work of the third or fourth centuries B. C., have been found. Prof. Quagliati, of the Museum of Tarranto, has cleverly reconstructed these, and considers them worthy of a place beside the famous figurines of Tauagia.

Perhaps the most beautiful of these is a wonderful group consisting of Eros kneeling upon the shoulders of Aphrodite. This, which is about 31 centimeters in height, has been restored to an almost perfect condition, and shows a unique conception very delicately and gracefully carried out. Another charming figure is that of a nude girl in a lovely and unusual pose, with the arm upraised.

Also a number of bronzes were found in tombs of later dates, belonging to the Roman period.—Translated for the SCIENTIFIC AMERICAN from the Illustrazione Italiana.

LIVE AND DEAD WEIGHT.

THERE is a popular notion, says The Lancet, that the weight of the living body is less than that of the dead one. In a recent issue of the Pioneer Mail, a correspondent discusses this question in connection with the behavior of a crocodile which he shot dead while it was basking asleep on a quicksand. When shot the crocodile began to sink and almost disappeared before it could be reached. The correspondent is clearly inclined to accept the popular notion of an increase of weight at death but for the fact that "recent experiments undertaken by some learned authorities in America had proved that a dead body was lighter than a living one. From this they (the learned authorities) deduced that the soul had a definite weight in pounds avoirdupois." It is possible that some of our readers are unfamiliar with the experiments to which the correspondent of the Pioneer Mail refers. They will be found in American Medicine for 1907, New Series, Vol. II., p. 240, and were made and recorded by Dr. Duncan Macdougall of Haverhill, Mass. Patients were weighed in the act of dying. The scales used recorded any increase or decrease beyond the fifth of an ounce—not a particularly delicate instrument for estimating the weight of that part of the living body which is usually re-

LE BLON.

Date.	Machine.	Place.	Distance.	Time. H. M. S.	Persons.	Remarks.
Oct. 18, 1909...	Monoplane	Doncaster	22 miles	0 30 00	1	On Bradford cup; flew in rain.
Oct. 19, 1909...	Monoplane	Doncaster	15 miles	....	1	Astonishing flight in a gale.
*Oct. 20, 1909...	Monoplane	Doncaster	....	....	1	Foolhardy flight in great gale.

F. W. BALDWIN.

Date.	Machine.	Place.	Distance.	Time. H. M. S.	Persons.	Remarks.
Mar. 12, 1908...	Biplane	H'mondsp't ...	319 ft.	....	1	With the Red Wing.
May 18, 1908...	Biplane	H'mondsp't ...	....	....	1	With the White Wing.
Mar. 18, 1909...	Biplane	Baddeck	....	....	1	With the Silver Dart.
Aug. 2, 1909...	Biplane	Petawawa	....	....	1	Several short flights.

LEGAGNEUX.

Date.	Machine.	Place.	Distance.	Time. H. M. S.	Persons.	Remarks.
Feb. 14, 1909...	Biplane	Mourmelon ...	1.2 miles	....	1	Pupil of Ferber.
Feb. 14, 1909...	Biplane	Mourmelon ...	6.2 miles	....	1	Sweeps two circles.
April 27, 1909...	Biplane	Vienna	2.5 miles	0 3 26	1	On a Voisin machine.
Aug. 6, 1909...	Biplane	Stockholm	3,280 ft.	....	2	With a passenger.
Aug. 22, 1909...	Biplane	Reims	6 miles	0 9 56	1	Won eighth prize for speed over 6 miles.

HENRI ROUGIER.

Date.	Machine.	Place.	Distance.	Time. H. M. S.	Persons.	Remarks.
May 23, 1909...	Biplane	Juvissy	18.6 miles	....	1	Swept eleven circles.
Aug. 29, 1909...	Biplane	Reims	....	....	1	Won fourth prize; altitude, 180 ft.
Sept. 9, 1909...	Biplane	Brescia	....	0 12 10	1	Reached 328 ft. altitude.
*Sept. 12, 1909...	Biplane	Brescia	31 miles	1 10 18	1	Reached 380 ft. altitude.
*Sept. 20, 1909...	Biplane	Brescia	....	....	1	Reached 650 ft. altitude.
*Sept. 28, 1909...	Biplane	Berlin	31 miles	0 54 00	1	Rises to 518 ft.
Sept. 29, 1909...	Biplane	Berlin	48 miles	1 35 00	1	In competition with Latham.
*Oct. 1, 1909...	Biplane	Berlin	80 miles	2 38 00	1	Wins first prize; distance.
Oct. 18, 1909...	Biplane	Blackpool	17.7 miles	0 24 43	1	Wins second prize; $3,600.

E. BUNAU-VARILLA.

Date.	Machine.	Place.	Distance.	Time. H. M. S.	Persons.	Remarks.
Aug. 5, 1909...	Biplane	Chalons	....	0 15 00	1	Voisin biplane presented by father.
Aug. 22, 1909...	Biplane	Reims	6.2 miles	0 13 30	1	Thirteenth prize for speed for 10 kilometres.
Aug. 29, 1909...	Biplane	Reims	18.6 miles	0 38 31	1	Eighth prize for speed for 30 kilo.

*Considered the most interesting flights on record.

garded as immaterial and imponderable. In the first of a series of six experiments Dr. Macdougall placed on the scales a man dying from pulmonary tuberculosis. The patient lost weight at the rate of one-sixtieth of an ounce per minute until the moment of death, when "the beam end dropped with an audible stroke," showing a sudden decrease of three-quarters of an ounce in weight. What was the cause of the sudden decrease? Dr. Macdougall, after excluding the loss due to escape of breath and fluid contents of the body by evaporation or other natural means, concluded that the marked and sudden decrease was due to escape of the "soul-substance." In this particular instance the "soul" was evidently a very material one, weighing three-quarters of an ounce. The experimenter extended his observations to dogs, but the results gained were negative. At the moment of death the dog's body refused to show any alteration in weight. We are of opinion that the correspondent of the Pioneer Mail, in seeking to explain the disappearance of the shot crocodile in a quicksand, need not take his "learned authorities" too seriously. Dr. Macdougall's observations are to be explained by a peculiar bias on the part of his scales or on the part of the "friends" who assisted him. At least the scales used by other investigators have refused to reveal any sudden diminution in the weight of the body at death. In the usual acceptation of the term, "death" occurs when respiration and circulation have ceased, but in a more strict sense the death of the body is gradual, the muscular system, for instance, being really alive some hours after the apparent death of the individual.

TRACED FORGERIES.*

IDENTITY OF SIGNATURES AS PROOF OF FORGERY.

BY ALBERT S. OSBORN, EXAMINER OF QUESTIONED DOCUMENTS.

A forgery is ordinarily proved by showing that it differs fundamentally from a genuine writing, but not every one knows that what appears to be the exact opposite of this statement may also be true; that is, that a forgery may be shown to be such because it is too much like a genuine writing. This is a distinction that must be carefully analyzed, or naturally it will lead to confusion.

A fraudulent reproduction of a writing is made either by imitating the genuine characteristics of a genuine writing, or by some process laboriously reproducing the exact outline of a model genuine writing. By the first method a simulated forgery is produced; by the second, a traced forgery. There are those who argue in defense of forgery, sometimes perhaps in good faith, that it is an irreconcilable contradiction to say that in one instance a writing is not genuine because it diverges, and in another that it is not genuine because it is an exact duplicate. Careful analysis of the subject, however, and an accurate statement of the conditions, explain the apparent paradox.

The central and important facts are: First, that a combination of divergences of significant characteristics proves forgery; and, second, that identity, or approximate identity, that shows that one writing was made from another by any process, is also proof of forgery. A popular statement on the subject is: "No two genuine writings are ever exactly identical." Strictly speaking, this, of course, is true, as it is difficult, if not impossible, to find any two things exactly identical. What is really meant is that, if two signatures are identical in a way that is inconsistent with the ordinary divergences in position, size, and proportions of genuine writing, then this identity is an indication of forgery.

Different writers differ greatly in habits of uniformity. Therefore it is always dangerous to make general statements on such a question; and, as already stated, the vital question to be considered always is whether the identity points to a fraudulent method of production. The courts and text-books have spoken on the subject with varying degrees of accuracy and positiveness, and a few excerpts may be of interest.

In the Matter of Rice, 81 Appellate Division (N. Y.), 223; 81 N. Y. Supp., 68 (1903), involving the same facts involved in the celebrated Patrick murder trial, the Court said:

"Upon a critical examination of these four signatures it will be found that they correspond almost exactly—a coincidence which could not possibly happen in the case of four genuine signatures of a person upward of eighty years of age. . . . In other words, each signature will nearly superimpose, showing a similarity which does not appear in the concededly genuine signatures introduced in evidence, and which, from the very nature of things, could not occur."

In Hunt v. Lawless, 7 Abbott's New Cases, 113 (1879), the Court says:

"Where two or more supposed signatures are found to be counterparts, I think the simulation is detected by that circumstance."

In Day v. Cole, 65 Mich. 129, 31 N. W. 823 (1887), the Court says:

"I am satisfied the signature is a forgery. All the facts seem to point in that direction; but the one thing that fastens conviction upon my mind above all others is this: These two signatures are too evenly alike to be both genuine."

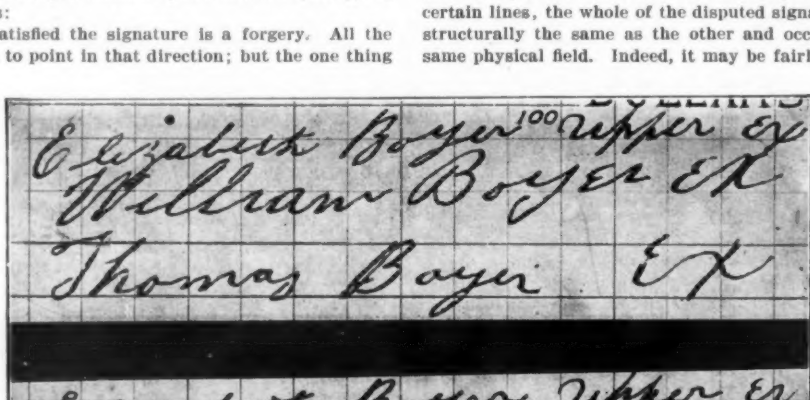
In Fox v. McDonogh's Succession, 18 Louisiana Annual, 448 (1866), the Court says:

"The remarkable and almost exact sameness of the size, form and position of each letter, line and flourish or dash in the space occupied by the signature to the proposed codicil, and that to the lease of November 1 (1846), . . . renders it not only possible, but probable, that the former was traced from the latter."

In Matter of Burtis, 43 Misc. (N. Y.) Reports, 437; 89 N. Y. Supp. 441 (1904), the Court says:

"True, there are slight departures occasionally from the model, but these variations are only in detail of certain lines, the whole of the disputed signature being structurally the same as the other and occupying the same physical field. Indeed, it may be fairly said that these very departures tend to indicate the process which has produced the signature, for it will be noticed that after each departure the line of the disputed signature immediately returns to the line of the model—showing conclusively, as I think, that there was a model which was steadily operating as a guide to the writer's hand."

In Matter of Koch, 33 Misc. (N. Y.) Reports, 153; 68 N. Y. Supp. 375 (1910), the Court says:



SIGNATURES ON RULED BACKGROUND SHOWING CLOSE IDENTITY.

* West Publishing Company's Docket.

"There is not the slightest deviation, except such as might and naturally would occur if both signatures were tracings from the same standard."

Finally, the editor of Abbott's Trial Brief, second edition, at page 400, in speaking of identity as proof of forgery says:

"It seems that such proof is conclusive, and would require instruction to the jury to that effect."

In the examination of any case the underlying principles to keep in mind are whether, as was said above, the identity "from the very nature of things could not occur," and, in addition to this, whether the identity indicates the process of tracing. As a matter of fact, there are skillful uniform writers, who write genuine signatures nearer alike than some traced forgeries resemble an actual model, although in the latter case such resemblance is of a character that shows unmistakably that the forged signature is a tracing from the original.

The character of the resemblances, therefore, must always be considered, and, what is more important, the character of the line of the disputed signature must also always, at least in some degree, indicate that the signature was not written, but drawn.

It is physically impossible to make a tracing with a normal writing movement, and in nearly every instance a suitably enlarged photograph of the model and an alleged tracing will show conclusively a distinction in line quality which in many instances is alone unmistakable proof of forgery. If such suspicious line quality is combined with striking similarity to a model, then the two facts confirm each other in the most convincing manner.

The most interesting testimony on this question of identity is, perhaps, that given by the late Prof. Benjamin Pierce, the celebrated mathematician of Harvard University, in the celebrated Sylvia Ann Howland case. It was found by careful examination and comparison under Prof. Pierce's direction that the probability of coincidence of each of the thirty downward strokes in this long signature was represented by the fraction of one-fifth, and Prof. Pierce testifies as follows:

"I have carefully examined the signatures 1 and 10 of Sylvia Ann Howland. I have placed them over each other, and have compared their magnified photographs. The coincidence is extraordinary, and of such a kind as irresistibly to suggest design, and especially the tracing of 10 over 1. . . . The relative frequency of coincidence expresses how often there is a coincidence in either of the characteristic lines, such as in line 1, for example. The product of the relative frequency into itself expresses how the coincidence of a characteristic line 1 is combined with that of line 2; the cube of the relative frequency of coincidence shows how often there will be the simultaneous combination of the coincidences of the first three lines, and so on.

"Finally, the relative frequency must be multiplied into itself as many times as there are characteristic lines, to express how often there can be a complete coincidence in position of all the lines of the signature.

"In the case of Sylvia Ann Howland, therefore, this phenomenon could occur only once in the number of times expressed by the thirtieth power of five [nine hundred and thirty-one quintillions of times, 931,000,000,000,000,000,000]. This number far transcends human experience. So vast an improbability is practically an impossibility. Such evanescent shadows of probability cannot belong to actual life. They are unimaginably less than those least things which the law cares not for."

This case has been incorrectly reported in nearly every reference to it in the decisions, the text-books, and magazine articles, even down to the year 1909. In the first place, the thirtieth power of five is not, as it has been reported, 2,666 followed by eighteen ciphers, but is 931 followed by eighteen figures. The difference in the numbers makes no practical difference in the argument, as the least is entirely beyond human comprehension. This strange error is in the original report of the case, and has been repeated from that time. No doubt some change was made in the basis of the calculation, without making the resulting change in the first reported result.

Another error that has been repeated in nearly every reference to the case is the statement that Prof. Pierce testified that "no two signatures will be identical," etc.; but his testimony applied only to the signatures "No. 1" and "No. 10" in this particular case. The testimony in full and a most interesting and valuable verbatim report of the arguments of counsel are on file at the Public Library at New Bedford, Mass.

This famous case was finally decided on a point of law, and the facts were never passed upon by Court and jury.

There are illustrated herewith signatures from the case of the Fidelity Trust Co. (Buffalo, N. Y.) v. Executors Lydia Cox Estate. This illustration was made with a superimposed glass carrying uniform squares over the signatures as photographed. It will be seen that there are three groups, of three signatures each, and the photograph renders it possible to make comparisons of size, proportions, and position by inspection, and shows unmistakably that the three groups of signatures could not have been produced excepting from each other or from a common model.

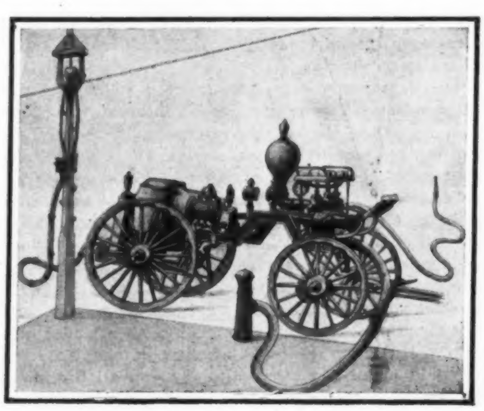
This character of illustration has been used in several important cases, and has recently been passed upon by the Supreme Court of New Jersey (1909) in the case of State v. Matthew J. Ready, 72 Atlantic Reporter, 495. This case was reversed by the Court of Errors and Appeals (75 Atlantic Reporter, 564) on other grounds, but the decision of the Supreme Court on this question is as follows:

"Nor did the fact that the photograph exhibited the signatures on a background of ruled squares destroy the admissibility of the offered picture. . . . So we think there was no error in the admission of these photographs."

AN EARLY ELECTRIC FIRE PUMP.

The application of electricity to the elimination of the fire hazard in large cities is not so recent as many people imagine. This application is now accomplished in big cities such as New York by locating small electric pumping stations in various parts of the city and connecting them hydraulically to the city water supply and electrically to some source of power, usually the lighting company's generating station. A system of pipes leading out from the pumping stations gives them control over a large area. In the event of a fire, the pressure at any part of the system can be raised in a few seconds to the necessary tension.

In the first development of this idea the pumping station was mounted on four wheels and carried directly to the scene of action. The accompanying illustration shows its construction. This practice had several advantages over the usual steam boiler and engine outfit. It was much lighter and would develop the necessary pressure in less time. By its use the usual accompaniment of smoke was entirely avoided.



AN EARLY ELECTRIC FIRE PUMP.

It was far less expensive than the present electrical method, for its hydraulic system consisted merely of a few feet of hose and its electric system of a few feet of wire. The apparatus was patented by Dr. Schuyler Skaats Wheeler, past president of the American Institute of Electrical Engineers, in the early years of the Crocker-Wheeler Company, which he founded.

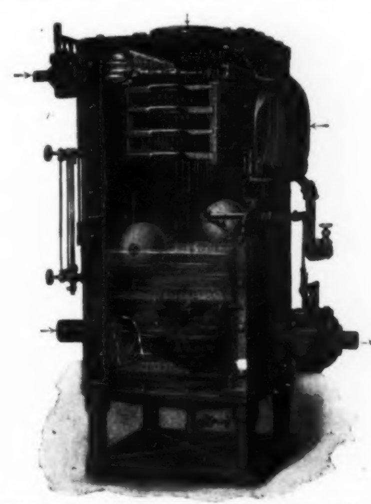
IMPROVED OPEN FEED-WATER HEATER.

The accompanying illustration shows an improved type of open feed-water heater which is a steam pump-works, which has just been put on the market. This heater is of new design and combines in its construction all the points of advantage that the "open" method of heating boiler feed water, or water for heating or drying systems, etc., allows over other methods ordinarily in use, and embodies other features of convenience and economy of operation.

In this apparatus the water is heated by direct contact with the exhaust steam, the heating capacity of which is utilized at its maximum degree, and there is no drop in the temperature at which the water leaves the heater, due to any collection of mud or scale. All impurities in the water, such as sand, floating particles, etc., are retained in the filter, and all scale-forming carbonates, air and other gases, so dangerous to the life of boilers, are removed, making the product leaving the heater pure, hot water, perfectly suitable for boiler feeding or other refined industrial purposes.

This heater combines in one apparatus the function ordinarily performed by several machines. It extracts all the oil from the incoming steam, and besides heating the water, it filters and purifies it. It contains also a storage tank for receiving the water of condensation. While all these functions are combined in one apparatus, its operation is so simple and so automatic that but little attention is required on the part of the engineer.

As will be clearly seen from the sectional view, this apparatus consists of a vertical, cast iron, rectangular shell, on one side of which, near the top, is located the exhaust steam inlet. The oil separator is built into the heater body just inside this inlet, and all the steam must pass through this separator before it can enter the heater. Inside the heater shell, at the top end, several shallow, removable, water trays are arranged, one beneath another, which are slightly inclined and partly perforated. Above these trays, on the opposite side from the steam inlet, is the cold water inlet trough, out of which the water supply, conducted through an automatically controlled valve, is spilled onto the trays. At the lower end of the shell the filter is located, the material of the filter bed consisting of coke, excelsior or other similar material. This material is confined between two perforated plates, and can be removed when necessary through doors provided for the purpose. Beneath the filter bed is a chamber from which the purified water is taken away by the feed pump. All the sediment collects in the lower part of this chamber and is drained away through a blow-off connection to waste. The receiving chamber occupies the space above the filter bed and is of extra large capacity so as to take care of the condensation from heating systems, etc., which is received in deluges from traps, pockets, radiators, etc., when they discharge their contents. An automatically controlled overflow at the top of the receiving chamber takes care of any dangerous excess of water, and this overflow extends the full width of the shell and forms a "skimmer," so that floating impurities can be "skimmed off" by simply holding open the cold water inlet valve until the heater fills to this point, when the impurities run off into the overflow and through the valve below, to waste. The feed pump suction is located at one side of the feed-water chamber, with a vent pipe leading up



IMPROVED OPEN-FEED WATER HEATER.

into the heater body for carrying away any vapors that may collect. An outlet is located at the top end of the heater shell which is used as exhaust outlet or vent pipe, as required, depending on whether the apparatus is used as a "thoroughfare" or "draw" heater.

In operation, all or part of the exhaust steam, as may be required, enters the exhaust inlet, where, moving at a high velocity, it strikes a peculiarly punctured and bent metal surface. The elastic steam rebounds and passes around to either side, while the oil, on account of its greater momentum, is carried through the punctured sheet against the back plate of the grating, where, out of the swirl of the steam current, it falls into the receiving well and drains away to waste. The oil cleansed steam now enters the heater shell and fills the space around the trays, where it comes into intimate contact with the water supply which is dropping from tray to tray in a finely divided condition. The water supply, entering through a float controlled valve, fills the distributing trough which extends across the shell and overflows from a serrated edge in a thin, even sheet onto the trays below. These trays, arranged one below the other, are slightly inclined and partially perforated, so that the water flows from one to the other over the lower serrated edge of each and through the perforations, being retarded in its progress so that it is thoroughly mixed with the steam before falling into the hot well below. Ample space is allowed around the trays so that the water in its finely divided state is heated to the highest possible temperature.

The difference in height between the normal water level in the well and the overflow level is sufficiently great to accommodate the sudden inrush of water from the traps, returns, etc., forming in this way an adequate storing chamber for the water thus received.

Two floats, properly located in the receiving cham-

ber, automatically control the operation of the apparatus; one, connected with the water inlet valve, regulates the cold water supply and maintains a constant water level, at the same time meeting the demands of boiler feed water supply, while the other, connected with the overflow valve, opens this valve when the overflow level has been reached and allows the excess water to escape to waste.

The water and condensed steam, after falling to the receiving chamber, percolate slowly through the filter bed and in this process, due to the heat of the water and the special design of the heater, the scale-forming carbonates in the water are precipitated and retained by the filtering material while the gases liberated pass out with the uncondensed steam through the vent pipe at the top of the heater. The purified and heated water drops into the settling chamber and is pumped away, a pure, hot water, free from mud and scale-forming matter, in perfect condition for boiler feed use. The heavy sediment collects at the bottom of the chamber and is drawn off when necessary through the blow-off connection below the heater body.

As will be seen from the statement given above, the operation of the apparatus is entirely automatic, and, under ordinary circumstances, requires no attention whatever. An occasional cleaning, as may be needed from time to time, and such inspection as every engineer gives to all parts of a plant in his charge, are all that is required. Every convenience is provided for this purpose, and no pipe joints have to be broken for any of the operations necessary. Pressures ranging from atmospheric pressure to five pounds above may be carried in the exhaust line without impairing the efficiency in any way and without requiring modification in the construction or operation of the heater.

LIGHT AND ELECTROMAGNETISM.*

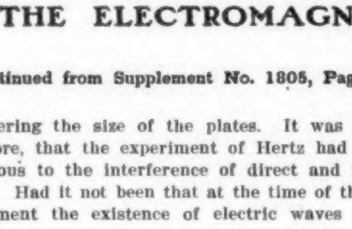
ELECTRIC WAVES AND THE ELECTROMAGNETIC THEORY OF LIGHT.

Continued from Supplement No. 1805, Page 87.

In opening his third lecture on the subject of Electric Waves and the Electromagnetic Theory of Light, Sir J. J. Thomson said that on the previous occasion he had repeated the most famous of the experiments of Hertz, in which that investigator had caused waves to strike on a reflecting plate, and then, by means of his detector, had investigated the effects produced in the neighborhood of this plate. In the speaker's repetition of the experiment, in his last lecture, he had shown that when the detector used was held near the plate, the neon tube became bright, and that the light faded if the detector were taken further away from the plate, to reappear later on. If sufficient space had been available, it would have been found that this disappearance and reappearance of the light took place periodically. When this experiment was first described, all thought that the results obtained were due to the interference of the direct and the reflected waves. It seemed an almost perfect analogue of an experiment of Lord Rayleigh's on the interference of sound waves, in which the note emitted by a shrill bird whistle was directed on to a reflector, and the space between the whistle and this reflector was examined, using a sensitive flame as a detector. In this case it was found that when the flame was in certain positions it flickered up and down, while if moved either in or out from such positions it became quiescent, though the flickering reappeared if the flame were moved a definite distance from its original position. This seemed, the lecturer continued, an exact analogue of the experiment shown in the last lecture. Instead of a Leyden jar, a whistle was used as the vibrator, and a sheet of metal instead of the reflector, and in place of the electrical detector a "sinking" flame was used. This experiment, as he had already stated, did more than anything else to secure an acceptation of Maxwell's theory. In his experiments, however, Hertz had used one size of detector only; and in order to avail himself of the effects of resonance, he had chosen his detector of such a length that it had the same period as the system exciting the waves. About the year after the experiments of Hertz, two Swiss physicists, Sarasin and De la Reve, repeated them, and got the same alternations of sparking and non-sparking found by Hertz. They used, however, detectors of different sizes, and found then that the distance between the apparent nodes depended on the size of the detector. If the effects arose from the interference of direct and reflected rays, as in Lord Rayleigh's bird-whistle experiment, the distance between two nodes should be half a wave-length. The Swiss experiment, however, showed that the distance between the nodes did not depend upon the wave-length, but, so to speak, on the size of the sinking flame. In fact, it was found that by altering the size of the detector this distance could have any value desired.

To demonstrate this, Prof. Thomson continued, he had modified the apparatus used in the last lecture, so as to get rather brighter effects. In the new arrangement the waves were directed along two parallel wires ending in plates fixed opposite to the plates of the exciter, as shown at D D^1 in Fig. 1. The other ends of the wires were free and the reflection took place from these free ends, when waves were excited by the passage of a spark between the balls of the exciter. Using first a large detector, the lecturer showed that when this was carried along the wires to one position the light was extinguished. Substituting a smaller detector, this extinction took place at an entirely different point, there being a considerable distance between the two nodes thus found. A detector of intermediate size would, he said, have given a node in an intermediate position. With the same detector the same position would, he continued, be found for the nodes, however the period of the exciting circuit were varied, as could be done by altering the size of the plates. It was obvious, therefore, that the experiment of Hertz had nothing analogous to the interference of direct and reflected waves. Had it not been that at the time of the Swiss experiment the existence of electric waves had be-

Fig. 1.

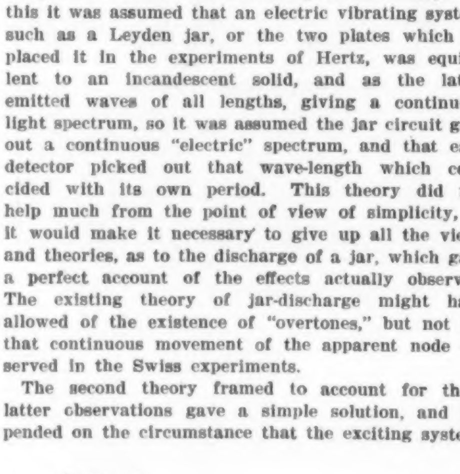


come well established in other ways, the effect would have had fatal results, and, as matters were, it caused great consternation, much as if the principal witness in an important law suit had broken down in cross-examination.

Various theories were put forward to explain the observations. The first of these theories might, he said, be called the continuous spectrum theory. In this it was assumed that an electric vibrating system, such as a Leyden jar, or the two plates which replaced it in the experiments of Hertz, was equivalent to an incandescent solid, and as the latter emitted waves of all lengths, giving a continuous light spectrum, so it was assumed the jar circuit gave out a continuous "electric" spectrum, and that each detector picked out that wave-length which coincided with its own period. This theory did not help much from the point of view of simplicity, as it would make it necessary to give up all the views and theories, as to the discharge of a jar, which gave a perfect account of the effects actually observed. The existing theory of jar-discharge might have allowed of the existence of "overtones," but not for that continuous movement of the apparent node observed in the Swiss experiments.

The second theory framed to account for these latter observations gave a simple solution, and depended on the circumstance that the exciting system,

Fig. 2.



which was supposed to be in more or less continuous vibration, was, as a matter of fact, hardly vibrating at all. In his last lecture he had pointed out that, by putting into the vibrating circuit a high resistance, vibration could be prevented, in which case the energy was expended in heating up the resistance, instead of being reconverted to and fro into potential and kinetic energy.

In a vibrator of the type used by Hertz there was a different cause of a loss of energy in the vibrating system. This loss was not due to the heat expended in the spark, but to the fact that the system was sending out energy in all directions by radiation; and as this did not come back, the system lost energy rapidly, and was, in fact, almost dead-beat. Birkeland had measured the rate of this loss, and found that after two or three vibrations the amplitude had fallen to an insignificant fraction of its original value. With a system of this kind, losing energy so rapidly, it was impossible to get true interference of direct and reflected waves as occurred in the experiment on sound. The effects, at any point, of the direct and the reflected waves had to occur at the same time; but as the two waves, to reach this point, had traveled different distances, the reflected wave having the longer path, it must have left the plate long before the direct wave. If then the oscillations died away very rapidly, the effects of each successive wave got weaker and weaker, and hence when the reflected and direct wave met, the former was large and the latter small, and could not therefore be expected to counterbalance the reflected ray, and thus there was no true interference.

How was it, then, Sir Joseph continued, that we got something analogous in its effects to interference? To answer this, he continued, let us imagine that the primary impulse was quite dead-beat—a shock, and nothing else. Then let us suppose this shock setting in vibration a system having a definite period like a pendulum. The system would be still in vibration when it was met again by the shock reflected back from the plate. Then, according to the time which had elapsed between the first and second meeting of the shock with the vibrator, it would either tend to increase the amplitude of the vibration or to annul it. With a fixed distance between the position of the vibrator and the reflecting-plate, the effect of the return shock would depend wholly on the "time of swing of the pendulum;" that was to say, on the period of the resonator, and not at all on that natural to the exciter.

It was, he continued, a most remarkable fact in scientific history that the one experiment which converted everybody was the very one which broke down on cross-examination. Following Hertz, he proposed, he continued, to show the reflection and refraction of these electrical waves, as well as their absorption by bodies analogous to tourmaline. He had not, he said, space in that room for apparatus on the same scale as Hertz, but would use smaller models. When a vibrator was placed along the axis of a parabolic sheet, the electric waves came out as a straight narrow beam, or, at least, should do so, since, in actual practice, it was difficult to get everything in such adjustment that there was no spreading whatever. Hertz's parabolic reflectors were 8 feet high, with their other dimensions to correspond. The models he would use were much smaller. One of the parabolic reflectors had along its axis a spark-gap connected up with a coil, while in the axis of the other a coherer, in circuit with a battery and an electric bell, was placed. With these the lecturer showed that the beam could be directed on to the coherer by the parabolic reflector, or if, alternatively, it was directed in another direction, it could be reflected into the coherer by means of a metallic plate. The lecturer subsequently repeated the experiment with the apparatus shown diagrammatically in Fig. 2. Here the spark-gap was fixed near one end of a rectangular box A open at the mouth and connected up to a coil B as indicated. The coherer was placed at the bottom of a rectangular tube as shown at C, and was coupled up to a battery and a relay as indicated. When the relay was closed by the current through the coherer, it completed the circuit of another battery through a small electric lamp.

As a further experiment the lecturer directed the beam from the spark-gap so as just to miss the mouth of the tube leading to the coherer, and then showed that by putting between the two a large prism of paraffin wax the beam could be bent round so as to enter the tube and operate the coherer.

He would next show, Prof. Thomson continued, an experiment analogous to the action of tourmaline on polarized light. When a suitable section of a tourmaline crystal was held in one position, it was quite transparent to a beam of polarized light, while if turned through a right angle it was opaque. **Taking**

* Engineering.

a system of wires wound parallel to each other on a frame, he showed that if this were placed in front of the exciter-box, so that the wires were parallel to the spark, the system was opaque to the beam emitted. When the system was turned round, however, so that the wires were at right angles to the spark, it was transparent to the beam, and the coherer was accordingly operated. He further showed that the screen, with its wires parallel to the spark-gap, could act as a reflector; but with the wires at right angles to this, the screen would not reflect the beam. The exciter, he continued, emitted lines of force parallel to the spark, and when these lines of force met wires also parallel to the spark, they could excite currents in them, and in that case the system of wires acted as a screen. With the wires at right angles to the line of force, no currents were excited in the direction of the length of the wires, and the screen acted as if transparent.

These experiments showed that the electric waves underwent reflection, refraction, and polarization. The study of their periodicity was much easier if, instead of allowing the waves to wander out in all directions, they were guided along wires. He proposed, therefore, to use a system similar to that shown in Fig. 3, with the exception that the ends *P* and *Q* were connected by a wire containing a short helix, in which could be placed one of Rutherford's detectors, consisting of small pieces of iron magnetized to saturation. The changes in the magnetization of these wires he would show by means of a magnetometer. On bridging the wires between two other points, he showed that in general almost the whole electrical effect passed across the bridge, the helix and its detector being short-circuited. If, however, the position of the bridge were adjusted so that the circuit round the detector had the same period as the remainder, then resonance came in, and very large effects were produced, the iron being rapidly demagnetized.

Since, Prof. Thomson proceeded, we had in this case a current flowing round a closed circuit, the wave-length must be equal to the length of this circuit, or an integral multiple of it. This fact was most useful, as, combining this information with the speed of propagation, the periodicity was at once obtained. Taking a neon tube round the closed circuit, when the latter was adjusted into resonance with the exciter, he showed that there were two nodes, and two only, in the circuit, so that the length of the latter was equal to the wave-length. A resonating circuit, he continued, might be quite separate from the exciting circuit, and we thus obtained a method of measuring wave-lengths which was the foundation on which all instruments for this purpose were based. Taking a circuit fitted with a neon tube and a movable bridge-piece, its length could be adjusted, so that when brought into the neighborhood of an exciter the tube became bright, in which case the wave-length of the primary circuit was equal to the length at that time of the closed circuit. The system of measurement had, the speaker continued, been brought to great perfection by Prof. Fleming in the latter's cymometer, which had been developed mainly for measuring the electric waves used in wireless telegraphy, which were generally several hundred yards long. In order to economize space the wires of the resonating circuit were accordingly wound as helices, thus getting a great length of wire into a small space. Space was further saved by having the wires connected to condensers of known capacity, and then an alteration in the length of the wire in circuit meant merely an alteration in the coefficient of self-induction, and the periodicity could be obtained from the fact that this varied with the square root of the product of the capacity and the self-induction. The cymometer in this way was well adapted for measuring the long waves used in wireless telegraphy; but for laboratory purposes, where physicists were mainly concerned with short waves, simple apparatus of the character shown by him that afternoon was quite sufficient and convenient.

(To be continued.)

AMATEURS AND ASTRONOMICAL DISCOVERY.

HOW AMATEURS CAN HELP ASTRONOMERS.

BY W. F. DENNING, F.R.A.S.

In recent years the progress of astronomical discovery has been very rapid. Photography has supplied an effective and prolific means of finding new and faint objects. Jupiter and Saturn's satellite systems have been considerably amplified by the work of Barnard, Pickering, Perrine, and Melotte; and we may, perhaps, wonder why the more outward planets, Uranus and Neptune, have not had some additions made to the known number of their moons; but possibly advances in this direction are on the eve of being realized.

In the detection of minor planets and comets, and in other departments of celestial investigation, we may easily recognize the valuable results achieved by photography, and there is every reason to suppose that future years will provide an increasing number of fresh discoveries.

Certainly in several fields of telescopic work the camera has not yet supplanted the visual observer. The discovery and measurement of double stars, the delineation of planetary detail, the observation and registry of meteors, etc., still depend upon the practised eye of habitual students.

In spite of the thoroughness of the successful labors already performed in the realm of astronomical discovery in late years, there is still a promising field for amateurs. The sky contains an inexhaustible store of objects, and though ordinary amateurs are handicapped in having to compete with the powerful appliances in many modern observatories, they can still hope to share in important discoveries.

Evidently the new, or rather unknown, objects awaiting detection are very small, faint, and difficult, and will require, for the most part, observers of ability and instruments of pretty considerable capacity to pick them up. Before Herschel's time the heavens were practically unexplored. Very few nebulæ and double stars were known; only one periodical comet had been found, and Herschel reaped a rich harvest later on by systematically examining the firmament.

To-day the conditions are all essentially different. The observer must needs explore ground which has been already surveyed again and again by the best instruments which human ingenuity has been able to construct, and by the most acute vision which masterly observers could command.

If we review the past, we shall find that amateurs can claim a fair share of the discoveries which have contributed so largely to the advanced state of our knowledge. But the amateur is unfettered; he can direct his energies to any particular branch, whereas the professional observer has his routine work, and this often consists in the determination of exact positions, which affords him no scope whatever for effecting new discoveries.

Amateurs of means can, of course, like the late Messrs. Common and Roberts, provide themselves with the apparatus necessary to insure success; but others with moderate or small appliances must needs pursue those branches specially suited to their circumstances. The latter will find an interesting field open to them in the observation of variable stars.

Comet-seeking is another field which, perhaps more than any other, offers the prospect of original and valuable work. A young observer, naturally ambitious to associate his name in a creditable manner with the science he loves, cannot take up any sphere of celestial work more likely to compensate him. To be the first to sight a new comet brings a world-wide notoriety, and such an achievement is well within the powers of ordinary observers with inexpensive telescopes.

The study of sunspots—their magnitudes, physical changes, etc.—is one specially commending itself to amateurs. Since Dawes discovered the nuclei in the umbræ of the spots, and Nasmyth announced the "willow-leaf" structure of the sun's outer envelope, we have had no very striking advances or discussions relative to sunspot phenomena, and it is certain that a variety of very interesting discoveries still awaits really capable observers.

With regard to lunar phenomena, it seems to me that the splendid photographs obtained by the 40-inch Yerkes refractor and other large instruments have rendered visual observation and drawings with small appliances obsolete. On several nights I compared the detail shown in the Yerkes photographs with that revealed in a good Calver reflector of 12.6-inch aperture, powers 312 and 440, and found that the telescope failed to enhance the photographic pictures. The scenery presented in the latter, its pretty nearly exhaustive character and reliable accuracy, render it more valuable for reference and comparison than the very imperfect and discordant delineations made by observers.

In the meteoric department there are many discoveries to be effected. New showers must be occasionally introduced into notice by the action of Jupiter and other planets, and there are systems with periodic returns only after long intervals of time. The sky should, therefore, be watched, so that any abnormal display may not pass without suitable recognition and record. And there are features in connection with the well-known showers of Boötids, Lyrids, Perseids, Aquaris, Orionids, and Leonids which promise new discoveries. Certain slow-moving fireballs appear to be isolated and to frequently fall from the constellations of the Zodiac.

In the department of planetary observation, amateurs have always taken a leading part, though it would seem, from the mass of results accrued after centuries of observation, we are still very far from a perfect knowledge of the facts. Comparatively small telescopes of 8-inch or 10-inch aperture are wonderfully effective in dealing with the minutiæ on the disks of Jupiter and Mars; but those who have used large and small instruments side by side claim that the former are superior, and their dictum can hardly be set aside, though the superiority appears to be slight in comparison to the great difference in the sizes of telescopes. It must be the ability of the observer which often compensates in a large degree for lack of instrumental power.

On Mars occasionally, and on Jupiter very frequently, there are evidences of striking changes discoverable with small glasses. Saturn sometimes displays large, irregular markings, as in 1903. The other planets are not so easily surveyed, nor so prolific in observable detail, though certain persons claim to have seen some anomalous and abundant features which future researches will eliminate rather than corroborate.

There still remains a rich and productive field for new and important discoveries by amateurs gifted with natural ability and prompted by love for the science. Valuable work in astronomy need not necessarily consist of discoveries. Systematic labors during which reliable observations are accumulated may lead up to useful generalizations and to form the equivalent to actual discoveries, for they often reveal new facts, and always at least provide material for investigation. When Heinrich Schwabe, of Dessau, in 1826, began his daily systematic observation of sunspots, he had no idea that the discussion of his results would finally lead to the detection of the periodicity of these phenomena. When Herschel commenced his sweeps for double stars and nebulæ, he formed no conception that he would meet with a major planet and effect one of the foremost discoveries of modern times!

In the future, as in the past, amateurs will undoubtedly claim a large share in the performance of good observational work. There has certainly been too much sensationalism in recent years. The go-ahead character of the times has, perhaps, induced this, and encouraged lively imaginations where it would have been better had there been calm and sound judgment. Faulty observations are not only misleading, but they retard and embarrass the progress of our knowledge. From the nature of things, however, serious mistakes and discordances among amateurs, both experienced and inexperienced, cannot be avoided. The ranks of amateurs are recruited from "all sorts and conditions of men," who have to pass no tests as to eyesight, judgment, or efficiency. Thus among the collection of individuals who survey the planets and search the heavens in quest of novelties, there are able, average, and incapable persons whose results on comparison must obviously present some remarkable contradictions. The very best observers may be drawn from any walk in life. The great French generals who rose to fame in the Napoleonic era were derived from widely different classes of the community. An erstwhile grocer, blacksmith, clergyman, policeman, doctor, or nobleman may possess an enthusiastic love for astronomy and the natural capacity to pursue it with advantage both to the science and to himself. Everything depends upon effort and inclination. History teaches us what has been accomplished in the past by men of all grades, and "history repeats itself," so that any man, however humble his station and modest his pretensions, may hope to distinguish himself in, and honorably associate his name with, the most sublime of all the sciences.—English Mechanic and World of Science.

ENGINEERING NOTES

The steel nosings of the piers of the Chaudiere Dam across the Ottawa River, Canada, were placed before depositing the concrete, and thus served as forms for the faces of the piers. The dam is of the sluice type, 1,300 feet long, consisting of 50 openings separated by concrete piers and closed with stop logs.

An unusual quantity of heavy rock work on the Panama Canal resulted in a requisition recently by the United States Government for some special cars of greater capacity and much heavier design than those ordinarily used in construction work. The specifications call for 42-gage double-track cars of 60,000 pounds capacity, the cars not to weigh less than 15,000 pounds.

A coal meter designed to measure the delivery of coal or other granular material has recently been patented. The device consists of a spiral vane inserted in the center of the delivery chute, and positively geared to a registering mechanism recording the downward movement of the column of material. The meter is of simple design. All parts coming in contact with the material measured are made of bronze to withstand corrosive or rusting action, and the gears and bearings run in a bath of oil. The index may be set to read in pounds, tons, cubic feet, or bushels, as desired.

The Canadian Minister of Railways recently announced that the construction of the Hudson Bay Railway will be begun by the government at once. The first work that will be given out is the bridge that is really the beginning of the road, which is to start from the Pas Mission, to which point the Canadian Northern has already built. It is not yet decided whether the mouth of the Nelson or the Churchill will be the northern terminus of the line, and a steamer carrying a location party will be sent north this summer to make a choice of the terminal point. In the meantime the construction of 160 miles of the line can be pushed on irrespective of the terminus. It is believed that the road will lead to the development of valuable iron ore deposits in a part of the country traversed.

The surveys of the Geological Department of the Government indicate that in Alaska the United States possesses enormous coal deposits. Already the work of the survey has covered a total of 8,106,880 acres of coal fields, and over three-quarters of a million acres of this area has been surveyed with such thoroughness as to convince the Geological Survey that coal mining can be profitably opened up. It is estimated that in these three-quarters of a million acres are over fifteen billion tons of coal that can be mined, and the Department is of the opinion that the fuel resources of this vast region will prove, when the surveys are complete, to amount to at least 150,000,000,000 tons. In addition to this, there are 90,000,000 acres of land that are geologically unexplored, but in which coal is known to exist.

About two years ago some walls made of cinder concrete were erected at Columbia University, and since then they have been subjected to five four-hour tests by fire, when the average temperature reached 1,700 deg. F. At the conclusion of each test a stream of water was applied for ten minutes while the walls were hot. Prof. Ira H. Woolson states in Insurance Engineering that, notwithstanding these tests, the walls for all practical purposes are as good as when erected, and he is of the opinion that within reasonable limits the percentages of coal and fine material in such cinders have very little effect on their fire-resisting qualities. The pieces of coal which were next to the surface in these walls were burned to ash, but the ash remained in place and acted as a non-conductor of heat. Several particles of pure coal were to be found within 2 inches of the surface.

In testing a series of base plates at the University of Illinois Mr. C. R. Dick experimented with various types of cushions for distributing the pressure of the plates uniformly over the lower surface. This required some form of elastic cushion between the plate itself and the very rigid bed of the testing machines. The cushions tested are thus described by Prof. N. C. Ricker in a recent bulletin of the Engineering Experiment Station, University of Illinois. A cushion was composed of several folded blankets, a folded woolen wrapper and two thicknesses of rubber packing, but it failed under moderate pressures, though not sufficiently to seriously injure the plates, except in the case of the cast iron. A cushion of dry sand forming a layer 2 inches thick was enclosed within a steel hoop a little larger than the plate, but the sand packed irregularly and failed to transmit a uniform pressure. A satisfactory cushion was finally composed of eleven layers of oak pieces, cut 24 inches by 3 inches by 7/8 inch piled in crosswise layers, leaving 1/4-inch spaces between the pieces to permit expansion. This cushion proved to be sufficiently elastic and also able to sustain pressures sufficient to break the cast iron plates. Indeed it supported without great injury a load of 620,000 pounds, or 31 times the safe pressure for which the plates were designed. Any injured pieces could easily be replaced in order to maintain the efficiency of the cushion.

SCIENCE NOTES

A society called the Christopher S. Lendentsoff Society for the Development of Experimental Sciences and their Practical Applications has been formed in connection with the Moscow Imperial Technical School, the objects of which are to assist discoveries and experiments in connection with natural science; to develop technical inventions and improvements; and to investigate and apply to practical use any scientific or technical discovery or improvement. The society expresses the hope that its aims will attract the notice of all similar institutions and persons working in scientific and technical spheres, and appeals for assistance to all such institutions and persons for any support which might be given by (*a*) interchange of correspondence; (*b*) a supply of lists of privileges and patents, and reports on scientific and technical subjects.

In the Comptes Rendus, M. Robin describes some experiments on the extinction of tone in iron. Bars of iron suitably supported give, on being struck, a principal note, the intensity of which is found to be a peculiar function of the temperature. With increase of temperature the intensity diminishes until, when 100 deg. is reached, the note can be no longer heard. As the temperature rises from 150 deg. to a dull red heat, the sound returns, attains a maximum, and again falls off to zero intensity. The "extinction interval" depends on the carbon-content of the iron or steel. It is 100-150 deg. for pure iron, 95-145 deg. for 0.2 carbon steel, and 85-120 deg. for 0.45 per cent carbon steel. The phenomenon was not observed in a steel containing 1.3 per cent carbon.

In the Scientific Proceedings of the Royal Dublin Society, W. Brown describes experiments to discover the best shape and dimensions of magnets; the same kind of steel being used throughout, and in the same physical condition. Sixteen samples were used, two of which were practically pure iron; the others contained various proportions of carbon, manganese, silicon, nickel, tungsten and cromium. The specific magnetization of each is tabulated at the date of preparation, and after one month and six months, and the percentage loss in the full period. From an examination of this table, Mr. Brown concludes that the retentivity of the magnets is improved by the presence of a small quantity of nickel, but diminished by larger percentages; though the original magnetic moment does not seem to be greatly affected thereby. In tungsten steels, an increase of 0.5 per cent of carbon and 12 per cent of tungsten caused an increase of 65 per cent in the magnetic moment, and increased the retentivity nearly three times. In chrome steels a low percentage of chromium seems to have a better effect than a higher; though when nickel is present it appears to mask the effect of chromium if the amount of the latter is small. Abt has published some results on the comparison of the magnetic moments of magnets having the same dimensions, and magnetized in the same field, but of different compositions, that is, crucible, diamond and tungsten steels. The magnetic moments were 33.7, 35.9 and 62.15; and at the end of four months the percentage losses were 1.1, 25.9 and 26.5 respectively. The last value is very high for tungsten steel; the chemical composition of the steels, however, is not given in the paper. In the present investigation, the best results were obtained from tungsten and chrome steels. In every case the magnetic moment is increased after a month's rest, due no doubt to the materials coming back to its state of molecular equilibrium after magnetization; then there is a gradual decrease in the moment until the magnet becomes permanent.

TRADE NOTES AND FORMULÆ.

To Attach Paper Labels to Iron.—Rub the iron at the desired spot thoroughly with an onion cut in half, and then stick the label, previously smeared with paste, gum or glue, to the spot.

To Bleach Ivory That Has Turned Yellow.—Allow it to lie for several hours in freshly slaked lime, or in a mixture of 0.5 part of fresh chloride of lime and 2 parts of water. When clean, dry it and allow it to lie in the air.

To Make Ivory Plastic.—The ivory having been freed from grease, is placed in a solution of phosphoric acid (1.13 specific gravity). When soft enough, wash in cold water. On placing it in water it again becomes non-transparent and hard.

Marbling on Enameled Objects (according to Grüchtel Bros.).—A priming coat is first applied and on this, by means of a brush, an enamel of another color is sprayed. After the drops have been made to run together by tapping, the object is dried in the ordinary manner.

Colored Pencils for Writing on Glass for Use in the Cellar or Warehouse.—Melt together, over a slow fire, 100 parts of spermaceti, 75 parts of tallow, 27 parts of wax and stir into it 150 parts of very finely pulverized red lead. Pour the mass in strips on moistened tablets. (In place of red lead other coloring substances can be used.)

Colored Pencils and Plastic Substance (W. Grüne). —To a concentrated solution of rosin or fat soap saturated with casein, as a body substance, add pulverized earths, earth colors, carbon or fibrous substances, with or without coloring matter. By the addition of salts of earth, metal or metals which form insoluble soaps, or casein soaps, a precipitate is produced, which incloses the body substance.

Bronze Colored Coatings for Iron.—Expose the brightly polished articles, freed from grease, for 2 to 5 minutes to the fumes of a heated mixture of concentrated hydrochloric and nitric acids (equal parts). Then, without touching them more than possible, heat them to a temperature of 572 deg. to 662 deg. F. (300-350 deg. C.) until the bronze color appears. Cool them, rub vaseline well into them and then heat again until the vaseline composes. After cooling rub again with vaseline. For pale reddish brown shades use concentrated hydrochloric and nitric acids; for oxide coating (fine bronze yellow) and acetic acid.

Fireproofing for Fabrics (according to Hayes).—Bone Ash, 10 parts; water, 50 parts; sulphuric acid, 6 parts; allow it to stand for two days, at moderate heat, then add 100 parts of water and filter it. The fluid is first mixed with a solution of 5 parts sulphate of magnesia (Epsom salts) in 15 parts of water and then with so much ammonia that the excess of the latter can be detected by the odor. The resultant deposit is pressed and dried. Two parts of this deposit are mixed with 1 part of tungstate of soda and 6 parts of wheaten starch, blued with a little indigo carmine, and then boiled with sufficient water to produce a viscid fluid, with which the fabrics are saturated.

To Harden Iron Superficially.—(a) Mix 2 parts potash, 16 parts burned ox-hoofs, or burned leather parings and 8 parts of soot-black, all finely pulverized, with ox-blood or tallow to a dough and spread the mixture thickly on the iron, heated to a dark red. The iron is then to be heated to redness and cooled in clean water. (The hoof horn and leather scraps must be heated to a brown, not black, coal, in an iron kettle and then pulverized.) (b) Thirty parts horn charcoal, 5 parts rasped wood, 10 parts potash niter, 60 parts common salt, 7.5 parts glue (salt previously roasted). (c) Eight parts soot, 8 parts salammoniac, 20 parts charcoal powder, mixed to a paste with a solution of carbonate of ammonia.

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